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Tonsillectomy for Obstructive Sleep-Disordered Breathing or Recurrent Throat Infection in Children

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U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
www.ahrq.gov

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Prepared by:
(redacted for peer review)

Investigators:
(redacted for peer review)

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of systematic reviews to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. These reviews provide comprehensive, science-based information on common, costly medical conditions, and new health care technologies and strategies.

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If you have comments on this systematic review, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

Andrew Bindman, M.D.
Director
Agency for Healthcare Research and Quality

Arlene Bierman, M.D., M.S.
Director
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Stephanie Chang, M.D., M.P.H.
Director, EPC Program
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Lionel Bañez, M.D.
Task Order Officer
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Christine Chang, M.D., M.P.H.
Task Order Officer
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

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Key Informants

(redacted for peer review)

Technical Expert Panel

(redacted for peer review)

Peer Reviewers

(redacted for peer review)

Tonsillectomy for Obstructive Sleep-Disordered Breathing or Recurrent Throat Infection in Children

Structured Abstract

Objectives. To systematically review evidence addressing tonsillectomy in children with obstructive sleep-disordered breathing (OSDB) or recurrent throat infections.

Data sources. Multiple databases from 1980-August 2015.

Review methods. We included comparative studies of tonsillectomy, perioperative medications to improve tonsillectomy outcomes, and postoperative medications for pain-related outcomes. We also included case series and database or registry studies with ≥1000 children to address harms. Two investigators independently screened studies and rated risk of bias. We extracted and summarized data qualitatively and quantitatively via Bayesian meta-analysis. We also assessed strength of the evidence (SOE).

Results. We identified 197 unique studies (63 low, 102 moderate, and 32 high risk of bias). Studies reported safety data more consistently than effectiveness outcomes. Populations, surgical approaches, anesthetic, analgesic, and anti-emetic regimens varied across studies, as did perioperative and postoperative agents or combinations of agents assessed. Relative to no intervention, most studies addressing tonsillectomy in children with OSDB reported better sleep-related outcomes in children who had a tonsillectomy, but improvements were modest and risk of bias in the studies was mixed. We did not find tonsillectomy to be superior to CPAP in the few included studies addressing this comparison. Similarly, few studies addressed special populations (e.g., Down Syndrome, obesity). Overall, children with recurrent throat infections undergoing tonsillectomy to improve number of infections, associated utilization (clinician visits), days of work/school missed, and quality of life had improvements in these outcomes in the first post-surgical year compared with children not receiving surgery. These benefits diminished over time, however, and data on the longer term outcomes are limited. Partial compared with total tonsillectomy was associated with faster recovery (return to normal diet or activity) but also a risk of tonsillar regrowth requiring reoperation. In studies comparing surgical techniques for tonsillectomy, frequently used "hot" techniques such as coblation and electrocautery were generally associated with faster recovery than was cold dissection. Overall, estimates of bleeding-related harms associated with tonsillectomy were low (<4% in meta-analyses). Studies of perioperative medications were heterogenous, but dexamethasone was consistently associated with less need for rescue analgesia and minimal bleeding. Pre-emptive perioperative anti-emetics were associated with less need for postoperative anti-emetics. Few studies of postoperative medications addressed the same agents or outcomes.

Conclusions. Tonsillectomy can effect modest short-term improvement in sleep outcomes and reduction in throat infections compared with no surgery in children with OSDB or recurrent throat infections (low-moderate SOE). Data on longer term results are lacking. This modest short-term improvement must be weighed against a relatively low risk of postoperative bleeding (high SOE). Surgical technique had little bearing on either outcomes (low SOE) or bleeding risk.

Perioperative use of dexamethasone and pre-emptive 5-HT receptor antagonist anti-emetics should be considered to improve pain and reduce vomiting in the immediate postoperative period (low SOE). Little evidence addressed the use of postoperative medications for pain-related outcomes.

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Executive Summary

Introduction

Tonsillectomy or adenotonsillectomy ("tonsillectomy") is the most common surgery performed in the U.S. and represents more than 15 percent of all surgical procedures in children under the age of 15 years.[1] The primary indication for tonsillectomy has shifted over the last 20 years from recurrent throat infections to obstructive sleep-disordered breathing (OSDB) and obstructive sleep apnea (OSA).[2, 3] Widely variable national and small area tonsillectomy rates are well-documented. In their seminal study, Wennberg and Gittlesohn found rates of tonsillectomy varied almost 12-fold across adjacent counties in rural Vermont with similar populations.[4] Variation in rates continue despite improved evidence and dissemination about indications.[5]

Indications for Tonsillectomy

Tonsillectomy has two primary indications: recurrent tonsillitis and obstructive sleep disordered breathing (OSDB). Recurrent or severe tonsillitis has been defined as (1) five or more episodes of true tonsillitis a year; (2) symptoms for at least a year; and (3) episodes that are disabling and prevent normal functioning.[6] No gold standard diagnostic test exists to etiologically implicate or predictably attribute symptoms to tonsillitis. In fact, consensus is lacking on what symptoms attributable to tonsillitis are considered "disabling." Surrogates often used for tonsillitis include sore throat and pharyngitis. However, the degree to which either of these terms reflects true tonsillitis is not known. Bacterial pharyngitis can be diagnosed via rapid testing or culture. It is not possible, however, to determine whether the tonsil represents the infectious nidus or if the suspected pathogen represents normal bacterial flora for a particular child's pharynx.

Currently, the most common indication for tonsillectomy is OSDB (i.e., breathing difficulties during sleep including OSA and upper airway resistance syndrome [UARS]). OSDB results from obstruction from or dynamic collapse due to upper airway soft tissue during sleep resulting in snoring, hypopnea, apnea, and restless sleep. Adenotonsillar hypertrophy can cause oropharyngeal crowding, thereby increasing the likelihood of symptomatic airway collapse during sleep. OSDB includes disorders ranging from simple snoring to OSA and can result in significant quality of life and health consequences. It has been associated with a five-point decrease in intelligence quotient (IQ), hypersomnolence, emotional lability, decreased attention, small stature, enuresis, cardiopulmonary morbidity, and missed school.[7] Evidence of the relationship is reinforced by the effectiveness of OSDB treatment in improving behavior, attention, quality of life, neurocognitive functioning, enuresis, parasomnias, and restless sleep, and reversal of associated cardiovascular sequelae.[8, 9] Moreover, OSDB occurs at especially high rates in subsets of children with developmental disorders and craniofacial syndromes, including Down Syndrome.

Key Decisional Dilemmas

Tonsillectomy is painful and is associated with odynophagia (painful swallowing) and dysphagia (difficulty swallowing) that can make it difficult to return to normal diet or stay hydrated, and can be associated with postoperative hemorrhage, nausea and vomiting. To help

minimize these concerns, clinicians may use perioperative antibiotics, steroids, anti-emetics, and pain medications (e.g., non-steroidal anti-inflammatory drugs [NSAIDs] and other analgesics).

Clinicians and parents need to know three key things: 1) what is the likelihood that the surgery will improve clinical outcomes around recurrent throat infections and sleep disorders; 2) what is the risk that the child will experience a harm, primarily bleeding, with the surgery; and 3) if surgery is indicated, what approach, in terms of both surgical technique and perioperative medical care, has been demonstrated to optimize effectiveness and minimize harms? We address these questions by reviewing the comparative data for effectiveness on a specific set of outcomes and also searching a broader set of studies for harms data in order to estimate the rates of the most common and most severe harms, namely bleeding, readmission, and reoperation. The results from this report will be widely applicable; however, lack of consistently reported modifier data (e.g., BMI, surgical indications) may limit its generalizability to every child.

Scope and Key Questions

Scope and Uses of the Review

The current review addresses the comparative effectiveness and harms of tonsillectomy in children with the most common indications for the procedure, namely, OSDB and recurrent throat infections. The review, nominated by the American Academy of Otolaryngology - Head & Neck Surgery Foundation, addresses key decisional dilemmas identified by stakeholders and through our preliminary scan of the literature in a comprehensive manner. The review also includes Key Questions (KQ) to improve understanding of outcomes in subgroups such as very young children (1-2 years old), children with Down syndrome, and those who are overweight or obese.

We anticipate this report will be of primary value to organizations that develop guidelines for tonsillectomy, to clinicians who provide care for children with indications for tonsillectomy, and for families making treatment decisions. Children who are candidates for tonsillectomy may be treated by clinicians including pediatricians, otolaryngologists, family physicians, nurses, nurse-practitioners, and physician assistants. This report supplies practitioners and researchers up-to-date information about the current state of evidence, and assesses the quality of studies that aim to determine the outcomes and safety of tonsillectomy.

Key Questions

We developed KQs in consultation with Key Informants and the Task Order Officer. KQs were posted for review to the AHRQ Effective Health Care website. We note that OSDB includes breathing difficulties during sleep as operationalized in each study, including obstructive sleep apnea and upper airway resistance syndrome. As noted, tonsillectomy includes tonsillectomy, partial tonsillectomy, and adenotonsillectomy. We also note that comparative effectiveness includes both the benefits and harms of interventions.

Questions were as follows:

KQ1. In children with obstructive sleep-disordered breathing (OSDB), what is the comparative effectiveness of tonsillectomy compared with continuous positive airway pressure (CPAP), or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1a. In children with OSDB and neuromuscular or craniofacial abnormalities, what is the comparative effectiveness of tonsillectomy compared with CPAP, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1b. In children with OSDB under age 3 years, what is the comparative effectiveness of tonsillectomy compared with watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1c. In children with OSDB and Down syndrome, what is the comparative effectiveness of tonsillectomy compared with CPAP, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1d. In children with OSDB who are overweight or obese, what is the comparative effectiveness of tonsillectomy compared with CPAP, weight loss, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ2. Among children with recurrent throat infections, what is the comparative effectiveness, including harms, of tonsillectomy compared with watchful waiting with supportive care (including pharmacologic—antibiotic or non-antibiotic—treatments) on the number and severity of throat infections, quality of life, and health care utilization?

KQ3. Do benefits and harms differ between partial tonsillectomy and total tonsillectomy?

KQ4. Do benefits and harms differ by surgical technique (e.g., cautery, coblation)?

KQ5. What are the benefits and harms of adjunctive perioperative (i.e., preoperative, intraoperative, or in post-anesthesia care) pharmacologic agents intended to improve outcomes?

KQ6. What are the benefits and harms of postoperative (i.e., after discharge from post-anesthesia care and up to 10 days post-surgery) pharmacologic agents intended to reduce pain-related outcomes?

Analytic Framework

The analytic frameworks illustrate the population, interventions, and outcomes that guided the literature search and synthesis (Appendix A of the main report). The frameworks depict the KQs within the context of population, intervention, comparator, outcomes, timing, and setting (PICOTS) parameters. In general, the figures illustrate how tonsillectomy may result in outcomes such as changes in sleep parameters, numbers of throat infections, quality of life, or health care utilization.

Methods

Literature Search Strategy

To ensure comprehensive retrieval of relevant studies of therapies for children undergoing tonsillectomy, we used three key databases: the MEDLINE® medical literature database via the PubMed® interface; EMBASE (Excerpta Medica Database),an international biomedical and pharmacological literature database via the Ovid® interface; and the Cochrane Library. Search strategies for KQs applied a combination of controlled vocabulary (Medical Subject Headings [MeSH] and Emtree headings) to focus specifically on tonsillectomy and harms of interventions. We restricted literature searches for KQs to studies published from 1980 to the present to reflect current techniques for tonsillectomy and perioperative or postoperative medications. Searches were last executed in August 2015.

We carried out hand searches of the reference lists of recent systematic reviews or meta-analyses of studies addressing pediatric tonsillectomy. The investigative team also scanned the reference lists of studies included after the full-text review phase for additional studies that potentially could meet our inclusion criteria.

Inclusion and Exclusion Criteria

Table A lists the inclusion/exclusion criteria we used based on our understanding of the literature, key informant and public comment during the topic refinement phase, input from the TEP, and established principles of systematic review methods. We used a best evidence approach to determine final inclusion of studies (i.e., if evidence from randomized studies or those with low risk of bias was insufficient to address a KQ or specific outcomes, we considered evidence from observational literature as well as factors related to the relevance of studies to determine if the inclusion of additional studies was warranted).[10]

Table A. Inclusion criteria for studies of tonsillectomy

Category	Criteria
Population	• Children with OSDB age 3-18 years, inclusive (KQ1) • Children with neuromuscular or craniofacial abnormalities and OSDB age 3-18 years, inclusive (KQ1a) • Children under age 3 years with OSDB (KQ1b) • Children with Down syndrome OSDB age 3-18 years, inclusive (KQ1c) • Children with obesity or overweight and OSDB age 3-18 years, inclusive (KQ1d) • Children with recurrent throat infection age 3-18 years, inclusive (KQ2) • Children with OSDB or recurrent throat infection undergoing tonsillectomy age 3-18 years, inclusive (KQ 4-6)
Intervention	• Tonsillectomy, adenotonsillectomy, or tonsillotomy (partial removal of tonsil) using any surgical approach (e.g., coblation, laser, cold dissection) (KQ 1-6) • Perioperative (preoperative, intraoperative, and immediate postoperative [post-anesthesia care] periods) NSAIDs, steroids, or anti-emetics (KQ5) • Any postoperative (discharge from post-anesthesia care to up to 10 days post-surgery) agent for pain (KQ6)
Design	• Effectiveness outcomes: Comparative studies (RCTs, prospective or retrospective cohort studies with comparison groups, nonrandomized trials, case-control studies) (KQ1-6) • Harms: Comparative studies (RCTs, prospective or retrospective cohort studies with comparison groups, nonrandomized trials, case-control studies), database or registry studies (harms of tonsillectomy), case series with at least 1000 participants (harms of tonsillectomy)
Other	• Original research (KQ1-6)

	• Publication language: English (KQ1-6) • Publication year: 1980-present (KQ1-2) or 2000-present (KQ3-6) • Reports one or more of the outcomes of interest • Sufficiently detailed methods and results to enable data extraction (KQ1-6) • Reports outcome data by target population or intervention (KQ1-KQ6) • Study assessed as low or moderate risk of bias

Abbreviations: KQ = Key Question; NSAID = non-steroidal anti-inflammatory drug; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Study Selection

Two reviewers independently assessed each abstract. If one reviewer concluded that the article could be eligible to address a KQ based on the abstract, we retained it for review of the full text. Two reviewers independently assessed the full text of each included study potentially addressing a KQ, with any disagreements adjudicated by a senior reviewer.

Data Extraction and Synthesis

We extracted data from included studies into templates that recorded study design, descriptions of the study population (for applicability), description of the interventions, and baseline and outcome data on constructs of interest. Data were initially extracted by one team member and reviewed for accuracy by a second. Extracted data for KQs are available in the Systematic Review Data Repository.

We summarized data for KQs qualitatively using summary tables where meta-analyses were not possible. We used a "best evidence" approach and focused on lower risk of bias studies where they provided sufficient data to address a KQ.[10]

We identified sufficient data to address post-tonsillectomy bleeding and bleeding-related readmissions or clinician visits using quantitative meta-analysis methods. We implemented a mixed-effects, arm-based meta-analysis to assess the influence of different surgical procedures as well as the effect of partial compared with full tonsillectomy on the occurrence of bleeding outcomes following surgery. We also conducted analyses to estimate the effects of including high risk of bias studies in the analyses. These analyses suggested no systematic effects of these studies; thus we retained them. Appendix E of the main report contains a full description of the meta-analytic methods.

Risk-of-Bias Assessment of Individual Studies

We used separate tools appropriate for specific study designs to assess quality of individual studies meeting eligibility criteria for our KQs. We used prespecified questions (Table 4 in *Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions*[11]) appropriate to each study design to assess risk of bias of RCTs and observational studies and a tool adapted from questions outlined in McMaster McHarms tool to assess reporting of harms.[12]

Two team members independently assessed each included study, with discrepancies resolved through discussion to reach consensus and/or adjudication by a senior reviewer. We then translated these ratings into standards for low, moderate, or high risk of bias, as described in the full report. Risk-of-bias ratings for each study are in Appendix F of the full report.

Strength of the Body of Evidence

Two senior investigators graded the strength of the evidence (SOE) for key intervention/outcome pairs using methods based on the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews.*[13] We assessed the domains of study limitations (low, medium, high level of limitation), consistency (inconsistency not present, inconsistency present, unknown), directness (direct, indirect), precision (precise, imprecise), and reporting bias (detected, unsuspected). The full team reviewed the final SOE designations. The possible grades were:

- High: High confidence that the evidence reflects the true effect. Further research is unlikely to change estimates.
- Moderate: Moderate confidence that the evidence reflects the true effect. Further research may change our confidence in the estimate of effect and may change the estimate.
- Low: Low confidence that the evidence reflects the true effect. Further research is likely to change confidence in the estimate of effect and is also likely to change the estimate.
- Insufficient: Evidence is either unavailable or does not permit a conclusion.[14]

Applicability

We assessed the applicability of findings reported in the included literature addressing KQs to the general population of children who are candidates for tonsillectomy because of OSDB or recurrent throat infection by determining the population, intervention, comparator, and setting in each study and developing an overview of these elements for each intervention category. We anticipated that areas in which applicability would be especially important to describe would include the indication for tonsillectomy, age at treatment, surgical technique, and population characteristics such as BMI, Down syndrome, or craniofacial abnormalities. Applicability tables for each intervention are in Appendix G of the full report.

Results

We identified 6903 nonduplicative titles or abstracts with potential relevance, with 1631 proceeding to full text review. We excluded 1414 studies at full text review. We included 197 unique studies (221 publications) in the review. These 197 studies included 156 comparative studies and 41 case series or database or registry studies providing data on harms only. The 197 unique included studies (reported in multiple publications) comprised 136 randomized controlled trials (RCTs), 10 nonrandomized trials, six prospective and four retrospective cohort studies, 18 database or registry studies, and 23 case series including ≥ 1000 children. We used database and registry studies and case series for harms data only. We considered 63 studies to have low risk of bias, 101 to have moderate risk, and 33 to have high risk.

KQ1. Effectiveness of Tonsillectomy vs. No Surgery for OSDB

We identified 10 unique studies addressing tonsillectomy in children with OSDB. Two RCTs and two cohort studies had moderate risk of bias. Four cohort studies had high risk. Given the relatively few studies addressing this question, we retained high risk of bias studies as part of the evidence base.

Two RCTs, two prospective, and one retrospective cohort study (all with moderate risk of bias) all reported improvement in the Apnea Hypopnea Index (AHI) in children after

tonsillectomy compared with observation (without intervention or with supportive/medical management, excluding CPAP). Differences between groups were statistically significant in two studies; not significant in two; and one study did not comment on significance. This benefit was consistent across age ranges (1-18 years), though data were most frequently available on children ages 4 to 12. Benefits seemed durable, with followup ranging from 6 months to 4 years.

Two RCTs and one retrospective cohort (moderate risk of bias) used several different parent-reported quality measures to assess sleep quality outcomes, limiting the ability to compare effectiveness directly across studies, although better outcomes were consistently associated with tonsillectomy. In one RCT and one prospective and one retrospective cohort study (moderate risk of bias) evaluating behavioral outcomes (emotional lability, attention, aggression) again using different measures, outcomes were consistently better among children receiving tonsillectomy. Executive function measures did not differ among children receiving tonsillectomy or no surgery in one RCT and one prospective cohort study, both with moderate risk of bias. Studies did not report other outcomes (e.g., utilization, cognitive outcomes) with frequency.

Two small studies (one moderate risk of bias RCT and one high risk of bias retrospective cohort study) compared tonsillectomy and continuous positive airway pressure (CPAP). Children in the RCT had concomitant Down Syndrome or mucopolysaccharidoses. Children receiving tonsillectomy had improved AHI scores compared with children receiving CPAP, but group differences were not significant in this small study. Although outcomes were reported to be superior in children receiving tonsillectomy in the cohort study, this high risk of bias, retrospective study can contribute little to our assessment of comparative effectiveness.

KQ1a. Effectiveness of Tonsillectomy for Children with OSDB and Neuromuscular or Craniofacial Abnormalities

Only a single RCT (moderate risk of bias) compared the efficacy of adenotonsillectomy to immediate initiation of CPAP in children with Down Syndrome and mucopolysaccharidoses who were diagnosed with obstructive sleep apnea by polysomnogram. As discussed above, both groups showed improvement in AHI at 6-month follow-up, with maintenance at 12-month follow-up (no significant group differences).

KQ1b. Effectiveness of Tonsillectomy for Children with OSDB Under 3 Years of Age

While several studies included children under 3, these data were not extractable from the aggregate data of the entire study population. Only a single high risk of bias retrospective cohort study focused exclusively on children age 2 and under and reported greater improvements in AHI in children receiving tonsillectomy compared with those receiving CPAP or other treatments. Limitations of this study include a very small medical management arm (n=12) and lack of generalizability, with 63/73 children having various significant comorbidities.

KQ1c. Effectiveness of Tonsillectomy for Children with OSDB and Down Syndrome

As noted, only a single RCT (moderate risk of bias) specifically recruited children with Down Syndrome. Data were reported along with children with mucopolysaccharidoses. This study is discussed in detail above.

KQ1d. Effectiveness of Tonsillectomy for Children with OSDB and Obesity

One retrospective cohort study examined a mostly overweight/obese population with OSDB. As noted above, the study reported a significant improvement in AHI in children who received tonsillectomy compared with those who did not; however, data were insufficient to suggest effect modification by obesity/overweight status in this single, small study.

KQ2. Effectiveness of Tonsillectomy vs. No Surgery for Recurrent Throat Infection

We identified nine unique studies addressing tonsillectomy specifically for recurrent throat infections. Four RCTs, one nonrandomized trial, and two retrospective cohort studies had moderate risk of bias, and one RCT and one nonrandomized trial had high risk of bias. Given the relatively few studies addressing this question, we retained high risk of bias studies as part of the evidence base. Sore throat days and diagnosed Group A streptococcal throat infections decreased consistently across studies in children who received tonsillectomy vs. no surgery/watchful waiting with supportive care in the short term (< 12 months).

In one RCT, school absences decreased in the tonsillectomy group compared with watchful waiting in the first year post-procedure, but the difference was not statistically significant in the subsequent years. In a nonrandomized trial differences in school absences were not significant between groups. Tw studies (one RCT and one nonrandomized trial) collected quality of life data, which were not markedly different between any of the study arms at the one-year time point. Overall, comparative effectiveness assessment of tonsillectomy vs. no surgery to improve number of throat infections, associated health care utilization, days of work/school missed, and quality of life shows a benefit in the first post-surgical year, with diminishing benefit over time.

KQ3. Effectiveness of Partial vs. Total Tonsillectomy

We identified 20 unique studies (18 RCTs—5 with low, 11 with moderate, and 2 with high risk of bias—and 2 nonrandomized trials with moderate risk of bias) addressing partial tonsillectomy compared with total tonsillectomy. In addition to comparing partial with total tonsil removal, most studies (n=13) also compared surgical techniques including microdebrider, laser, coblation, and electrocautery partial tonsillectomy and cold dissection, coblation, and electrocautery total tonsillectomy. In studies comparing both partiality/totality and different surgical techniques (e.g., partial coblation vs. total electrocautery), it is not possible to determine whether effects are due to the technique or due to the amount of tissue removed. Thus, except for in those studies that compared partial or total removal of the tonsils using the same technique (e.g., partial cold dissection vs. total cold dissection), we considered the comparison of interest broadly as partial vs. total tonsil removal. Across studies, “partial” tonsillectomy was variously or not explicitly defined.

Few studies reported the same outcomes, and few reported significant differences between partial or total removal. In studies comparing total and partial cold dissection, children receiving partial tonsillectomy had significantly faster return to normal diet in the two RCTs (low and moderate risk of bias) addressing this outcome. Two small RCTs with low and moderate risk of bias addressed outcomes following partial vs. total coblation or electrocautery and reported only on return to usual diet or activity. In the coblation study, children in the partial tonsillectomy arm

consumed a significantly greater percentage of normal diet and were engaged in a greater portion of normal activity than were children in the total tonsillectomy arm at all time points assessed. Similarly, in the one study comparing partial vs. total electrocautery tonsillectomy, children in the partial tonsillectomy arm had a significantly faster return to normal activity than did children in the total tonsillectomy arm.

Among the 9 studies of low or moderate risk of bias addressing partial vs. total tonsillectomy without using the same surgical technique, in two studies with low and moderate risk of bias, obstructive symptoms including snoring worsened in the short term in the partial tonsillectomy arm compared with total tonsillectomy, but differences between groups were not significant at longer-term followup (12-24 months) post-tonsillectomy. In a third RCT, no children in either group had snoring or apnea at 1 and 3 years postoperatively. In all six studies addressing return to normal diet, children receiving partial tonsillectomy had more favorable outcomes compared with those receiving total tonsillectomy. As with diet, in five RCTs children undergoing partial tonsillectomy had a more favorable return to normal activity than did children who had total tonsillectomy in (significant differences in two). In three of the four studies addressing throat infection, children who had partial tonsillectomy had more throat infections than did those in the total tonsillectomy arms, though differences were not statistically significant in three studies. Three studies addressed quality of life or behavioral outcomes with no significant group differences.

Across all studies, 14 out of an estimated 220 children (6.4%) had tonsillar regrowth after partial tonsillectomy, 12 of whom ultimately underwent completion of total tonsillectomy as a revision surgery.

KQ4. Effectiveness of Surgical Techniques

We identified 58 unique studies (53 RCTs. 4 nonrandomized trials, and 1 prospective cohort study) comparing surgical techniques for tonsillectomy. Eighteen studies had low risk of bias, 27 had moderate risk, and 13 had high risk. Most studies reported harms data (see Harms of Tonsillectomy section below). Nineteen studies (17 RCTs and 1 nonrandomized trial)—eight with low and 11 with moderate risk of bias—reported on return to normal diet or activity, the only usable effectiveness outcomes reported. Five RCTs and one nonrandomized trial compared coblation and cold dissection tonsillectomy. Across these small, short-term studies, coblation tonsillectomy was generally associated with faster recovery. Four studies reported on return to normal diet, with faster return associated with coblation in two studies and no significant group differences in two studies. Return to normal activity occurred significantly earlier after coblation in three low risk of bias studies.

Electrocautery was generally associated with more favorable results in three small RCTs comparing it to cold dissection. Two studies reported more favorable results associated with electrocautery, while results did not differ in the third. Return to activity was significantly faster in the electrocautery arm in one study, but no different in two others.

Four RCTs with moderate risk of bias compared coblation and electrocautery tonsillectomy with mixed results. Children undergoing coblation returned to normal diet more quickly than those undergoing electrocautery tonsillectomy in two studies, but recovery did not differ significantly between groups in two others. Children undergoing coblation also returned to normal activity roughly two days more quickly than those receiving electrocautery in two studies.

Three RCTs with moderate risk of bias evaluated tonsillectomy with a harmonic scalpel (which uses ultrasonic frequency to cut and cauterize tissue) compared with electrocautery, coblation, or cold dissection. Studies compared different measures of recovery, thus limiting our ability to draw conclusions about differences in effectiveness, though faster recovery was associated with harmonic scalpel in all studies. Only two small RCTs addressed laser tonsillectomy or thermal welding tonsillectomy and did not provide sufficient data to draw conclusions about effectiveness compared with more standard techniques.

Harms of Tonsillectomy

In order to account fully for potential harms of tonsillectomy, primarily post-tonsillectomy hemorrhage (PTH), readmission and reoperation, we compiled all comparative studies and examined rates of harms by arm, then reviewed case series and database studies, which were not included in the effectiveness analysis. We did not assess harms separately by indication because there is no reason to expect that they would differ; therefore, we do not separate them into the KQ1 and KQ2 results sections but combine surgical harms here.

We present the data obtained from comparative studies that were generally of higher quality followed by that of the case series and database studies and comment on their consistency. Finally, we conducted a Bayesian meta-analysis to estimate predicted rates of primary PTH, secondary PTH, reoperation and readmission by partial and total tonsillectomy, and by surgical approach.

Unadjusted rates of harms reported in comparative studies. One-hundred and three comparative studies of low or moderate risk of bias reported harms data. The 8160 children across studies who were treated with total tonsillectomy experienced 278 episodes (3.4%) of PTH. Few children required reoperation to control PTH (n=78/8160), and 68 had nonoperative revisits or readmissions for PTH. Children undergoing tonsillectomy with harmonic scalpel had the highest rate of PTH (11%), although few children underwent this procedure (n=397). Few children also had laser tonsillectomy (n=189), with 5.3 percent experiencing PTH. Rates were similar among techniques that are more commonly used: cold dissection had a rate of 3.9 percent; electrocautery had a rate of 3.4 percent; and coblation had a rate of 2.5 percent. Rates of revisits and reoperations overall were low, typically less than 6 percent.

PTH rates did not exceed 3 percent among the 20 study arms contributing data to asses bleeding in partial tonsillectomy. Rates were highest for coblation tonsillectomy (2.7%). No PTH was associated with laser approaches, but few studies assessed this modality. Rates of revisits for pain, dehydration, or postoperative nausea and vomiting (PONV) in studies of partial and total tonsillectomy were typically less than 10 percent. Other harms reported were largely minor and included burns or unspecified breathing complications. No study reported deaths.

Meta-analysis of harms data. Seventy studies evaluating partial or total tonsillectomy contributed data to the meta-analysis (63 RCTs, 6 nonrandomized trials, and 1 prospective cohort study). Twenty-two studies had low risk of bias; 36 had moderate risk; and 12 had high risk. In sensitivity analyses, high risk of bias studies did not affect findings, so we included them in final analyses. Rates of primary bleeding associated with total tonsillectomy in the meta-analysis were consistently low, all below 2 percent and with overlapping confidence bounds. Electrocautery was associated with the highest rate of secondary bleeding (occurring >24 hours post-procedure), with an estimate of 3.6 percent (95% Bayesian Credible Interval [BCI]: 2.0% to 5.4%). Rates of

readmission ranged from 0 percent to 6 percent. Although laser was associated with the highest estimated risk of readmission, the confidence bounds were very wide. Overall, estimates of bleeding and utilization harms associated with tonsillectomy are low.

Primary bleeding associated with partial tonsillectomy was predicted to be below 3 percent regardless of technique, and secondary bleeding below 2 percent. Data on readmissions and reoperations were sparse; thus confidence bounds are wide, and it is difficult to predict rates with any certainty.

Unadjusted rates of harms in case series and database studies. Forty-one studies addressed harms (13 low risk of bias, 23 moderate, and 5 high, not included in analyses). Overall, 2 percent of children in case series experienced a PTH episode. Unadjusted PTH rates in case series, database, or registry studies were generally in line with those reported in comparative studies (2% overall vs. 3.5% overall). Few children required readmission or reoperation for PTH (0.62% to 2%). Few cases of revisits for pain, dehydration, or PONV (rates ranging from 1%-7%) were reported in the nine studies providing such data. Three deaths were reported across case series or database studies. Other harms reported in these studies were disparate and typically not clinically significant

KQ5. Effectiveness of Perioperative Medications to Improve Outcomes

Forty-eight studies (47 RCTs—23 low, 21 moderate, and 3 high risk of bias—and one nonrandomized trial with high risk of bias) addressed perioperative NSAIDs, steroids, or anti-emetics. Most studies addressed the outcomes of return to normal diet or activity or need for rescue medications, which we defined as the need for additional or higher doses of pain medications or anti-emetics beyond those given as part of the standard surgical protocol. Doses, routes of administration, combinations of agents, and comparators differed across studies. Followup was limited to <7 days post-procedure, with most studies reporting outcomes in the immediate postoperative period (post-anaesthesia care unit [PACU] and up to 24 hours).

NSAIDs. Fifteen RCTs evaluated NSAIDs. In two studies of diclofenac, postoperative consumption of opioids was significantly lower in diclofenac groups compared with placebo, but analgesics typically did not differ between groups in three trials comparing diclofenac and other analgesics or diclofenac in combination with other agents and placebo. Analgesic needs typically did not differ by group in three studies comparing perioperative ibuprofen (with or without other agents) and placebo or other analgesics. In two studies comparing ketoprofen and including a placebo arm, results were mixed, with significantly lower analgesic needs associated with ketoprofen in one and no group differences in another. One study each addressed lornoxicam and ketorolac, and both reported no differences in analgesic use between these agents and comparators (placebo, fentanyl)

A single moderate risk of bias study evaluating effectiveness of peritonsillar bupivacaine infiltration vs. diclofenac suppository reported no difference in antiemetic rescue use between arms. In two RCTs comparing diclofenac with or without other analgesics to lidocaine or placebo, time to normal activity or diet did not differ significantly between groups.

Six studies of NSAIDs reported six episodes of PTH in 277 treated children (2.6%). Three cases of PTH were associated with diclofenac, two with ibuprofen, and one with ketorolac. Two studies (one of ketorolac and one of lornoxicam) reported no cases of PTH.

Steroids. Twenty RCTs evaluated steroids. Three of four trials of dexamethasone at escalating doses, or escalating doses and placebo, or doses of dexamethasone compared with ondansetron or placebo showed no differences in postoperative analgesic requirements by dose. In one placebo controlled trial children who received dexamethasone required significantly less analgesia. Five of eight studies comparing intravenous (IV) dexamethasone and placebo found steroid treatment to reduce postoperative analgesic requirements significantly. In four RCTs comparing IV dexamethasone and other comparators (IV methylprednisolone, oral gabapentin, IV acetaminophen, IV ketamine), results varied, with two studies reporting less use of analgesia associated with dexamethasone arms, one reporting no differences between dexamethasone and methylprednisolone, and one reporting no differences between dexamethasone and acetaminophen. Two studies comparing IV and infiltrated dexamethasone both found infiltrated dexamethasone to reduce postoperative analgesic requirements significantly, while another study comparing dexamethasone infiltration, levobupivacaine infiltration, and placebo reported lower analgesic use in the dexamethasone arm compared with the other groups.

Two dose escalation trials reported significantly reduced anti-emetic use in groups treated with dexamethasone vs. placebo, and two of five RCTS comparing IV dexamethasone and placebo reported significantly reduced antiemetic use in children treated with dexamethasone. Studies comparing dexamethasone and other comparators reported lower use of anti-emetics associated with dexamethasone vs. analgesic infiltration; no differences in comparing dexamethasone and methylprednisolone; and less need for anti-emetics with combination dexamethasone and ketamine or dexamethasone alone than placebo. A single RCT comparing IV vs. infiltrated dexamethasone vs. placebo reported significantly lower rescue anti-emetic use in both steroid groups compared with placebo and no differences between active groups.

Two RCTs assessed whether steroids affected time to return to normal diet with favorable effects associated with steroids in one and no group differences in another. In one RCT, time to normal activity was increased in children treated with IV dexamethasone vs. no steroid.

Ten studies reported PTH or PTH-associated utilization (9 study arms addressing dexamethasone and one addressing methylprednisolone). Three steroid studies explicitly noted no bleeding. The overall rate of PTH associated with steroids was 4.6 percent, with rates of revisits/readmissions or reoperation for hemostasis below 2 percent. Few studies evaluating perioperative agents reported any revisits for non-bleeding indications.

Anti-emetics. Five RCTs evaluated the effect of perioperative antiemetic use on post-tonsillectomy analgesic requirements. All studies evaluated 5-hydroxytryptamine (5-HT) receptor antagonists including ramosetron, granisetron, ondansetron, and dolasetron. Antiemetic medications did not have any effect on pain control in any trial. Pre-emptive use of 5-HT receptor antagonists reduced the need for immediate postoperative anti-emetic use compared with placebo in three RCTs.

KQ6. Effectiveness of Postoperative Medications to Reduce Pain-Related Outcomes After Tonsillectomy

Of 11 studies addressing postoperative medications for pain-related outcomes identified, ten were RCTs and one was a nonrandomized trial (4 studies with low, 5 with moderate, and 2 with

high risk of bias). Study drugs included steroids (prednisolone), NSAIDs (diclofenac, ibuprofen, celecoxib, aspirin), non-NSAID analgesics (acetaminophen) and antibiotics (amoxicillin). Four trials addressed effectiveness outcomes and evaluated heterogeneous agents. In those comparing analgesics (celecoxib, acetaminophen with or without ibuprofen, ibuprofen, diclofenac), need for rescue medications typically did not differ among study groups; all trials assessing analgesia outcomes had short-term followup (24 to 48 hours postoperatively). Time to return to normal diet was significantly better in one study in children receiving acetaminophen compared with diclofenac and did not differ in another receiving acetaminophen with morphine or with ibuprofen. Two studies of steroids reported no differences in return to normal diet and activity associated with steroid vs. no steroid over longer term followup (≥5 days).

Discussion

Key Findings and Strength of Evidence

KQ1. Effectiveness of Tonsillectomy vs. No Surgery for OSDB

Relative to no intervention, most studies reported better sleep-related outcomes in children who had a tonsillectomy, but improvements were modest and risk of bias in the studies was mixed. In five studies that included children whose OSDB was confirmed with polysomnography, AHI scores improved more in children receiving tonsillectomy than in those with no surgery (significant group differences in 2 studies). Sleep-related quality of life and negative behaviors (e.g., anxiety, emotional lability) also improved more among children who had tonsillectomy. Changes in executive function were not significantly different. We did not find tonsillectomy to be superior to CPAP in the few included studies addressing this comparison. The two studies comparing these interventions had inconsistent results, with one study favoring tonsillectomy and the other reporting no difference in AHI. Both studies were small and included selected subsets of children (e.g., significant comorbidities or under 24 months old).

The strength of the evidence is low for greater improvement in AHI after tonsillectomy compared with no surgery; moderate for a modest improvement in sleep-related quality of life; and low for no effect on negative behaviors with tonsillectomy compared with no surgery (Table B). Strength of the evidence is insufficient to assess effects on executive function and insufficient to assess effects on other outcomes including cognitive changes (IQ), cardiometabolic outcomes, and health care utilization, which were all addressed in single studies.

Strength of the evidence is insufficient to assess effects on AHI or sleep-related quality of life in two small studies with high to medium study limitations assessing tonsillectomy compared with CPAP.

KQ1a. Effectiveness of Tonsillectomy for Children With OSDB and Neuromuscular or Craniofacial Abnormalities

While studies may have included some children with craniofacial abnormalities, only a single, small RCT compared the efficacy of tonsillectomy to immediate initiation of CPAP in children with OSDB and concurrent Down Syndrome or mucopolysaccharidoses. Both groups showed improvement in AHI at 6-month follow-up, with no significant group differences in AHI at 12 months.

Strength of the evidence is insufficient to assess effects on AHI or sleep-related quality of life as only one small study with moderate risk of bias evaluated these outcomes (Table B).

KQ1b. Effectiveness of Tonsillectomy for Children With OSDB Under 3 Years of Age

While several studies included children less than 3 years of age, these data were not extractable from the aggregate study population data. Only one high risk of bias retrospective cohort study focused exclusively on younger children (≤2 years of age). The study reported greater improvements in AHI in children receiving tonsillectomy compared with those receiving CPAP or other treatments.

Strength of the evidence is insufficient to assess effects on AHI in one small, high risk of bias study (Table B).

KQ1c. Effectiveness of Tonsillectomy for Children With OSDB and Down Syndrome

As noted above, only a single RCT specifically recruited children with Down Syndrome and reported data aggregated with those of children with mucopolysaccharidoses. Both modalities (tonsillectomy and CPAP) were equally effective at improving AHI, with no significant group differences.

Strength of the evidence is insufficient to assess effects on AHI in a single, small study with moderate risk of bias (Table B).

KQ1d. Effectiveness of Tonsillectomy for Children With OSDB and Obesity

One retrospective cohort specifically evaluated a mostly overweight/obese population (75% of children) with PSG-proven OSDB and reported a significant decrease in AHI in children who received tonsillectomy compared with those who did not. Strength of the evidence is insufficient to assess effects on AHI using only a small, high risk of bias study (Table B).

Table B. Summary of evidence in studies addressing effectiveness of tonsillectomy in children with OSDB

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
Tonsillectomy vs. no surgery in children with OSDB	2 RCT (456) 2 Prospective cohort (135) 1 Retrospective cohort (32)	AHI	Low for greater improvement of AHI with tonsillectomy compared with no surgery	Significant but modest improvement in tonsillectomy vs. no surgery groups in 1 RCT and 1 retrospective cohort study; no significant group differences in 1 RCT and 1 prospective cohort; significance not assessed in 1 prospective cohort
	2 RCT (456) 1 Retrospective cohort (32)	Sleep-related quality of life	Moderate SOE for modest improvement in sleep-related quality of life after tonsillectomy vs. no surgery	Significant improvements in tonsillectomy vs. no tonsillectomy groups on measures of sleep-related quality of life in 2 RCTs and 1 cohort study in the short term
	1 RCT (397)	Behavioral outcomes	Low SOE for no effect on negative	Significant improvements in tonsillectomy vs. no surgery in 1 RCT

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
	1 Prosepctivecohort (38) 1 Retrospective cohort (32)		behaviors after tonsillectomy vs. no surgery	and 1 retrospective cohort; no significant differences in 1 prospective cohort; differences in measurement time frames across studies (7 months-4 years)
	1 Prospective cohort (38)	Cognitive changes (IQ)	Insufficient SOE	Overall IQ declined slightly in both groups over 4 year followup in one small study with moderate risk of bias—differences between groups not significant
	1 RCT (397) 1 Prosepctive cohort (38)	Executive function	Insufficient SOE	Significant improvements in caregiver-rated measures in tonsillectomy vs. no surgery in both studies but not in teacher-rated measures in 1 RCT; differences in followup time and medium study limitations preclude conclusions
	1 RCT (397)	Cardiometabolic outcomes	Insufficient SOE	One RCT reported no changes in cardiometabolic measures (insulin, lipids)
Tonsillectomy vs. CPAP in children with OSDB	1 RCT (73) 1 Retrospective cohort (73)	AHI, sleep-related quality of life	Insufficient SOE	Significant AHI improvement in tonsillectomy arm vs. CPAP in one small retrospective study with few children in CPAP arm; no group differences in RCT. No group differences in quality of life one small RCT with moderate risk of bias
Tonsillectomy vs. CPAP in children with OSDB and craniofacial abnormalities	1 RCT (73)	AHI, sleep-related quality of life	Insufficient SOE	No group differences in AHI or quality of life in a single, small RCT
Tonsillectomy vs. CPAP in children with OSDB under age 3	1 Retrospecitve cohort (73)	AHI	Insufficient SOE	Insufficient evidence due to one, small, high risk of bias study
Tonsillectomy vs. CPAP in children with OSDB &DS	1 RCT (73)	AHI, sleep-related quality of life	Insufficient SOE	No group differences in AHI or quality of life in a single, small RCT
Tonsillectomy vs. no srugery in children with OSDB and obesity	1 Retrospective cohort (33)	AHI	Insufficient SOE	Significant improvements in AHI in tonsillectomy vs. no surgery arm in a single, small cohort study with high study limitations in which >60% of children in each group were overweight or obese

AHI = Apnea Hypopnea Index; CPAP = continuous positive airway pressure; DS = Down Syndrome; IQ = intelligence quotient; Non-RCT = nonrandomized trial; OSDB = Obstructive Sleep-Disordered Breathing; SOE = strength of the evidence; RCT = Randomized Controlled Trial

KQ2. Effectiveness of Tonsillectomy for Recurrent Throat Infection

Although studies assessed infection rates and a number of utilization measures, such as missed school in the short term, longer term results were rarely reported, and studies that did report longer term results suffered from high attrition and incomplete data. In addition, "throat infection" was not defined consistently across studies and rarely was bacterial infection confirmed. Overall, children undergoing tonsillectomy to improve number of throat infections, associated health care utilization (clinician visits), days of work/school missed, and quality of life had improvements in these outcomes in the first post-surgical year compared with children not receiving surgery. These benefits diminished over time, however, and data on the longer term outcomes are limited.

We considered strength of the evidence to be moderate for a modest reduction in throat infections or streptococcal infections after tonsillectomy versus no surgery in the short term (< 12 months) (Table C). We considered the strength of evidence for reduction of infections in the longer term to be insufficient and to be low for no difference in streptoccocal infection reduction in the longer term. Strength of evidence is low for reduction in utilization (clinician visits) in the short term; low for improvements in missed school in the short term; low for no difference in missed school over the longer term; and low for no differences in quality of life after tonsillectomy compared with no surgery.

Table C. Summary of evidence in studies addressing effectiveness of tonsillectomy in children with recurrent throat infections

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
Tonsillectomy vs. no surgery	5 RCT (576) 2 Non-RCT (557) 1 Retrospective cohort (290)	Throat infection	Moderate SOE for modest reduction in throat infection after tonsillectomy vs. no treatment in short-term (12 months)	Lower rates of throat infection in tonsillectomy arms in short-term with narrowing of gap in longer-term followup
	5 RCT (576) 2 Non-RCT (557) 1 Retrospective cohort (290)	Throat infection	Insufficient SOE for reduction following tonsillectomy vs. no surgery over longer term (>12 months)	Insufficient data based on lack of long-term data and high attrition rates in studies
	3 RCT (345) 1 Non-RCT (78) 1 Retrospective cohort (290)	Streptococcal infection	Moderate SOE for reduction in streptococcal infection after tonsillectomy vs. no tonsillectomy in short term (≤12 months)	Lower rates of streptococcal infection in tonsillectomy arms in short-term with narrowing of gap in longer-term followup
	3 RCT (245) 1 Non-RCT (28) 1 Retrospective cohort (290)	Streptococcal infection	Low SOE for no difference in reduction in streptococcal infection after tonsillectomy vs.no surgery over	Lack of significant group differences in longer term followup in 3 RCTs and 1 non-RCT; similar proportion of infections in retrospective cohort; and significantly more infection in non-surgical groups in 2 RCTs

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
			longer term (2-3 years)	
	1 Retrospective cohort (290)	Streptococcal infection	Insufficient SOE for no difference in effects after 4 years of followup	One small study with moderate risk of bias reported 4 year followup; no significant group differences
	1 RCT (231) 1 Non-RCT (303) 1 Retrospective cohort (10951)	Utilization (clinician contacts)	Low SOE for reduction in clinician contacts after tonsillectomy vs. no surgery in short term (<12 months)	Fewer consultations in tonsillectomy arms vs. no surgery, but high loss to followup and differences in outcome assessment
	1 RCT (231) 1 Non-RCT (303)	Quality of life	Low SOE for no difference in quality of life after tonsillectomy vs. no tonsillectomy	Modest improvements in quality of life in both groups; high attrition in both studies
	4 RCT (345) 1 Non-RCT (78)	Missed school or work	Low SOE for greater improvements in missed school after tonsillectomy vs. no surgery in short term (≤ 12 months)	Significantly fewer missed days in tonsillectomy arms vs. no surgery in 2 RCTs with medium study limitations at 12 month followup; no differences in third RCT
	4 RCT (245) 1 Non-RCT (28)	Missed school or work	Low SOE for no difference in effects between in longer term (>12 months)	No significant differences between groups in all studies at longer-term followup; medium study limitations

Non-RCT = nonrandomized trial; SOE = strength of the evidence; RCT = Randomized Controlled Trial

KQ3. Effectiveness of Partial vs. Total Tonsillectomy

Twenty studies compared partial to total tonsillectomy, but only six compared partial and total using the same surgical technique. Four studies compared partial versus total cold dissection and reported no differences other than a faster return to normal diet for partial tonsillectomy. Among those comparing partial and total coblation or partial and total electrocautery, return to normal diet and activity were more favorable in children undergoing partial tonsillectomy compared with total.

Most studies evaluated partial vs. total tonsillectomy using differing surgical techniques, and we considered the comparison of interest in these to be "partial vs. total," although it is not possible to be certain that effects are due to the surgical technique rather than the amount of tissue removed. Differences between partial and total tonsillectomy were generally not significant for outcomes related to OSDB persistence, quality of life, or behavior in these studies.

In six studies, children in the partial tonsillectomy arms had faster return to normal diet and normal activity compared with total tonsillectomy; however, these effects may be due to confounding by indication as surgical indication varied across studies. Across all studies, 14 out of an estimated 220 children (6.4%) had tonsillar regrowth after partial tonsillectomy.

We considered strength of the evidence to be low for no difference in effects on OSDB persistence; low for faster return to normal diet after partial tonsillectomy; and insufficient to

assess effects on throat infection in studies comparing partial versus total cold dissection tonsillectomy. Strength of the evidence is insufficient to assess effects on return to normal diet or activity in studies comparing either partial and total coblation tonsillectomy or partial and total electrocautery tonsillectomy given that only a single study addressed these outcomes. We considered strength of the evidence to be low for a more favorable return to normal diet and activity in children undergoing partial versus total tonsillectomy and low for no difference in effects on long-term (>12 months) persistence of OSDB symptoms, quality of life, behavioral outcomes, or throat infections in studies comparing mixed techniques (Table D).

KQ4. Effectiveness of Surgical Techniques for Tonsillectomy

Only 19 studies identified for this KQ reported recovery-related outcomes (return to normal activity and/or diet). Frequently used "hot" techniques such as coblation and electrocautery were generally associated with faster recovery (as measured by return to normal diet or activity) than was cold dissection. Few studies, typically addressing different measures and using different comparison techniques, addressed newer techniques such as thermal welding, laser, or harmonic scalpel, thus limiting our ability to draw conclusions about these approaches.

Strength of the evidence is low for a faster return to normal activity associated with coblation compared with cold dissection tonsillectomy and low for a faster return to normal diet associated with electrocautery compared with cold dissection tonsillectomy (Table D). We considered the strength of the evidence insufficient to assess effects of other surgical techniques (e.g., laser, thermal welding, harmonic scalpel) on these outcomes given that studies were typically small and evaluated different measures (e.g., dietary intake score, number of children consuming normal diet, parental return to work).

Harms of Surgical Techniques

Overall, estimates of bleeding and utilization harms associated with tonsillectomy are low. In meta-analyses, rates of primary and secondary PTH associated with total and partial tonsillectomy were consistently low, below 4 percent for any technique and with overlapping confidence bounds. Pooled rates (without adjustment) of PTH were low overall (3.5% in total tonsillectomy; 1.2% in partial tonsillectomy) in comparative studies. Unadjusted rates of revisits for pain, dehydration, or postoperative nausea and vomiting (PONV) were also low (< 2%). Other harms were disparate and generally not clinically significant (e.g., thermal burn from a cautery apparatus). No comparative studies reported deaths. Rates of harms in case series and database or registry studies generally aligned with rates from comparative studies. Three deaths were reported in case series including 1292993 children.

Strength of evidence is high for minimal PTH and PTH-associated utilization (readmissions or revisits) associated with both partial and total tonsillectomy (Table D). Strength of the evidence is low for minimal revisits or readmission for dehydration associated with partial tonsillectomy and moderate for minimal non-bleeding readmissions/revisits associated with total tonsillectomy. Data are insufficient to assess effects on admissions or revisits for pain or PONV associated with partial tonsillectomy given the few comparative studies addressing the outcome.

Table D. Summary of evidence in studies addressing effectiveness and harms of tonsillectomy techniques

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
Total vs. partial cold dissection tonsillectomy	1 RCT (101) 1 Non-RCT (1023)	OSDB persistence	Low SOE for no difference in effects on OSDB persistence between partial or total tonsillectomy	In both studies children in partial arm had snoring or apnea in short term but no group difference in longer followup**;** low SOE given few studies addressing outcome
	2 RCT (131)	Return to normal diet	Low SOE for faster return to normal diet after partial vs. total tonsillectomy	Children undergoing partial tonsillectomy returned to normal diet approximately 4 days sooner than children undergoing total tonsillectomy according to parent report
	1 RCT (101)	Throat infection	Insufficient SOE	More episodes of undefined tonsillitis during 6 year followup in partial arm, but insufficient data to assess effects on throat infections given single, small study
Partial vs. total coblation tosnillectomy	1 RCT (69)	Return to normal diet or activity	Insufficient SOE	Children in partial tonsillectomy arm engaged in significantly greater portion of normal activity and consumed greater percent of normal diet but insufficient data to assess effects on return to normal diet or activity given single, small study
Partial vs. total electrocautery tonsillectomy	1 RCT (40)	Return to normal activity	Insufficient SOE	Children in partial tonsillectomy arm engaged in significantly greater portion of normal activity and consumed greater percent of normal diet but insufficient data to assess effects on return to normal diet or activity given single, small study
Total vs. partial tonsillectomy (mixed techniques)	6 RCT (620)	Return to normal diet or activity	Low SOE for more favorable return to normal diet and activity in children undergoing partial vs. total tonsillectomy	Children undergoing partial vs. total tonsillectomy had consistently favorable outcomes but unit of measure varied across studies (e.g., mean days, N children)
	3 RCT (214)	OSDB persistence	Low SOE for no difference in effects on long-term persistence of OSDB symptoms between partial and total tonsillectomy	More children undergoing partial vs. total tonsillectomy had short-term snoring or obstructive symptoms in 2 studies but no group differences in longer term in any study
	2 RCT (159)	Quality of Life (≥12 months post-tonsillectomy)	Low SOE for no long-term differences in quality of life after partial vs. total	Improvements from baseline in both groups in 2 small studies, but no significant group differences in quality of life in either study

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
			tonsillectomy	
	2 RCT (159)	Behavioral Outcomes (≥12 months post-tonsillectomy)	Low SOE for no long-term differences in behavioral outcomes after partial vs. total tonsillectomy	Improvements from baseline in both groups on the Child Behavior Checklist in 2 small studies, but no significant group differences in either study
	4 RCT (296)	Throat Infections (≥12 months post-tonsillectomy)	Low SOE for no effect on throat infections following partial vs. total tonsillectomy	More throat infections or sore throats following partial vs. total tonsillectomy in 3 of 4 RCTs but no significant group differences
Total coblation vs. total cold dissection tonsillectomy	6 RCT (276)	Return to normal activity	Low SOE for faster return with coblation	Coblation, compared with cold dissection, associated with moderately faster return to normal activity in 4 small studies
	4 RCT (255)	Return to normal diet	Insufficient SOE	Faster return with coblation in 2 studies, no differences in 2 studies; all small studies with medium limitations
Total electrocautery vs. total cold dissection tonsillectomy	3 RCT (254)	Return to normal diet	Low SOE for faster return with electrocautery	Electrocautery, compared with cold dissection, associated with faster return to normal diet in 2 studies and not significantly faster in a third
Other techniques for total tonsillectomy (laser, thermal welding, harmonic scalpel)	10 RCT (906) 1 Non-RCT (305)	Return to normal diet or activity	Insufficient SOE	Heterogenous, small studies evaluating different outcome measures
Partial tonsillectomy	Meta-analysis 16 RCT (1234) 2 Non-RCT (1216)	PTH and PTH-associated utilization	High SOE for minimal bleeding associated with partial tonsillectomy	Rates did not exceed 3% for PTH; fewer data available to assess associated utilization, but rates are likely low given the low rate of PTH
	3 RCT (221)	Readmissions/ revisits for dehydration	Low SOE for minimal dehydration revisits/readmissions associated with partial tonsillectomy	5 readmissions reported across 3 study arms
	3 RCT (221)	Readmissions for PONV or pain	Insufficient SOE	Few studies provided data on these outcomes; rates low where provided

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
Total tonsillectomy	Meta-analysis 52 RCT 6 Non-RCT 2 Cohort studies (8069)	PTH and PTH-associated utilization	High SOE for minimal bleeding associated with total tonsillectomy	Low rates of PTH and PTH-associated utilization in both meta-analysis and unadjusted analyses (<6% associated with commonly used techniques)
	17 RCT (2269) 1 Prospective cohort (29) 1 Retrospective cohort (145)	Readmissions for pain, PONV, dehydration	Moderate SOE for minimal non-bleeding readmissions/revisits associated with total tonsillectomy	In 37 study arms, overall rates for non-bleeding revisits/readmissions were below 2%

Non-RCT = nonrandomized trial; OSDB = Obstructive Sleep-Disordered Breathing; PTH = post-tonsillectomy hemorrhage; SOE = strength of the evidence; RCT = Randomized Controlled Trial

KQ5. Effectiveness of Adjunctive Perioperative Medications to Improve Outcomes After Tonsillectomy

Studies addressing this KQ were heterogeneous, addressing multiple agents, combinations of agents, routes of administration and dosage, timing of agents, and rescue medications provided. This heterogeneity limits our ability to draw conclusions about perioperative medications.

NSAIDs. Trials evaluating perioperative use of NSAIDs reported that diclofenac administration generally reduced immediate postoperative pain requirements compared with placebo. Results from the five trials involving ibuprofen or ketoprofen inconsistently showed reduced analgesic need in the PACU. A single trial of lornoxicam showed no difference in 24 hour analgesic requirement. In contrast, the one study of perioperative ketorolac showed reduced pain medication needs in the PACU, but not over the first 24 hours. A single study found no effect of NSAIDS on reducing anti-emetic use. NSAIDs were not associated with a faster return to normal diet or activity.

Steroids. Most placebo-controlled steroid trials (5/8) found that perioperative intravenous dexamethasone administration reduced the need for analgesics immediately after surgery (PACU and up to 24 hours postoperatively), but no longer term results were reported. Two studies reported that peritonsillar infiltration of dexamethasone also reduced immediate postoperative analgesic requirements (PACU, surgical day ward) compared with placebo.

Five RCTs found perioperative steroid administration decreased postoperative anti-emetic use in the immediate postoperative period (PACU and up to 24 hours postoperatively). Steroids had little effect on return to normal diet in two RCTs.

Anti-emetics. Data were consistent in terms of antiemetic medications. All five trials of 5-hydroxytryptamine (5-HT) receptor antagonists found their administration to have no effect on postoperative analgesic requirements. Three trials consistently reported reduced postoperative antiemetic requirements in patients treated with intraoperative 5-HT receptor antagonists.

We considered the strength of the evidence for studies with placebo comparison in most cases given the heterogeneity of agents and comparators. We considered the drug class (instead of individual agent such as diclofenac) in assessing strength of evidence for NSAIDs and anti-emetics (Table E). All steroid studies addressed dexamethasone.

NSAIDs. Strength of the evidence is low for reduced need for analgesia and for no effects on return to normal diet or activity with perioperative NSAIDs given inconsistent findings in small studies. It is also low for minimal PTH and associated utilization. Evidence is insufficient to assess non-bleeding related readmissions or revisits as few studies addressed these outcomes.

Steroids. Strength of evidence is low for a reduced need for analgesics or anti-emetics associated with steroids (IV or infiltrated dexamethasone). While most studies reported reductions associated with perioperative steroids, roughly half of studies addressing each outcome reported no group differences. PTH and related utilization was low across studies (moderate strength of evidence for minimal bleeding). Evidence is insufficient to assess the effects of steroids on return to normal diet as the studies addressing the outcome compared different combinations (one had a placebo comparator and the other assessed dexamethasone plus tropisetron) and reported inconsistent results. Only one study addressed return to normal activity (insufficient strength of evidence). Evidence was also insufficient to assess non-bleeding related readmissions or revisits as few studies reported these outcomes.

Anti-emetics. Strength of evidence is moderate for no effect of 5-HT perioperative anti-emetics on postoperative analgesia requirements and low for reduced need for postoperative anti-emetics given the small number of children evaluated in these studies.

KQ6. Effectiveness of Postoperative Medications for Pain After Tonsillectomy

Few studies addressed the same interventions and comparisons, and studies typically reported on need for rescue pain medication, PTH, and return to normal diet or activity as outcomes. The data on whether NSAIDs decrease rescue pain medication in the first 24 to 48 hours after surgery are conflicting, and no long-term data are available. Two studies compared prednisolone and placebo and found no effect on return to normal diet or activity.

PTH rates overall were low. The rates of PTH in steroid and placebo arms in the two studies addressing that comparison were similar. Bleeding rates in studies comparing NSAIDs (celecoxib, ibuprofen) and non-NSAID analgesics to placebo or other medications were also similar.

Strength of evidence is low for no difference in effects on return to normal diet or activity between steroids and placebo (Table E). Strength of the evidence for the effect of postoperative analgesics on need for rescue medications or return to normal diet or activity is insufficient given that no studies addressed the same agents and comparators. Strength of evidence for PTH associated with steroids is low for no difference between steroids and placebo or no treatment and insufficient for PTH associated with other postoperative medications as no studies evaluated the same agents and comparators.

Table E. Summary of evidence in studies addressing effectiveness and harms of perioperative or postoperative medications

Intervention and comparator	Type/Number of Studies (Total N Participants)	Key Outcome(s)	Strength of Evidence (SOE) Grade	Findings
Perioperative NSAID vs. placebo	2 RCT (180)	Return to normal diet and activity	Low SOE for no difference in return to normal diet or activity with NSAIDs vs. placebo	No significant group differences in 2 small studies with medium study limitations
	5 RCT (345)	Need for rescue analgesic	Low SOE for reduced need for rescue analgesia with NSAIDs vs. placebo	Significantly less need in 4 small studies, no group differences in a 5th study
Perioperative NSAIDs	6 RCT (277)	PTH and PTH related admissions/revisits	Low SOE for minimal PTH or PTH-related revisits/readmissions associated with perioperative dexamethasone	Rates of PTH or associated utilization <3% (unadjusted analyses) in 277 children receiving NSAIDs
	1 RCT (20)	Non-bleeding readmissions/revisits	Insufficient SOE	0 readmissions in one study reporting outcome
Perioperative dexamethasone vs. Placebo	10 RCT (979)	Need for rescue analgesic	Low SOE for reduction in analgesic need with dexamethasone vs. placebo	Significantly less need for analgesics after dexamethasone (IV or infiltration) vs. placebo in 7 small studies; no significant differences in 3 studies; inconsistency precludes higher SOE
	8 RCT (812)	Need for rescue anti-emetic	Low SOE for reduction in anti-emetic need with dexamethasone vs. placebo	Significantly less need for anti-emetics after dexamethasone vs. placebo in 5 small studies; no significant differences in 3 studies; inconsistency precludes higher SOE
	2 RCT (354)	Return to normal diet or activity	Insufficient SOE	Faster return to diet associated with steroids in one study and faster return to activity in second study
Perioperative dexamethasone	9 RCT (873)	PTH and PTH-related revisits/readmissions	Moderate SOE for minimal PTH or PTH-related revisits/readmissions associated with perioperative dexamethasone	Rates of PTH or associated utilization <5% in 873 children receiving steroids
	4 RCT (279)	Non-bleeding	Insufficient SOE	Few studies reported any outcome

		readmissions/re visits		
Perioperative anti-emetics	5 RCT (964)	Need for rescue analgesic	Moderate SOE for no effect of anti-emetics (5-hydroxytryptamine [5-HT] receptor antagonists)	No significant group differences in 5 RCTs comparing 5-HT antagonists with other anti-emetics, other 5-HT antagonists, or placebo
	3 RCT (303)	Need for postoperative rescue anti-emetic	Low SOE for reduced need for postoperative anti-emetics with perioperative 5-HT anti-emetics vs. placebo	Significantly less need for postoperative anti-emetics in 3 small RCTs comparing 5-HT antagonists and placebo; imprecision precludes higher SOE
Postoperative prednisolone vs. placebo	2 RCT (331)	Return to normal diet or activity in longer term (≥5 days)	Low SOE for no difference in effects of prednisolone vs. placebo on return to normal diet or activity	Number of children consuming normal diet or engaging in normal activity did not differ at 14 days post-tonsillectomy in one study; time to return to normal diet or activity did not differ in second small RCT
	2 RCT (331)	PTH	Low SOE for no difference in PTH associated with steroids vs. placebo/no treatment	Numbers of PTH in steroid and placebo arms were similar in 2 studies (13 PTH in steroid arms vs. 15 in placebo/no treatment)
Postoperative NSAIDs	2 RCT (564) 1 Non-RCT (115)	PTH	Low SOE for minimal bleeding	Unadjusted rates of 0-6% in 3 studies; higher rates associated with celecoxib
Postoperative analgesics (NSAIDs, non-NSAID analgesics)	2 RCT (157)	Return to normal diet or activity	Insufficient SOE	Outcomes defined differently in 2 small studies
	3 RCT (500)	Need for rescue analgesics	Insufficient SOE	Studies compared different analgesics and different rescue medications

Non-RCT = nonrandomized trial; NSAID = non-steroidal anti-inflammatory drug; OSDB = Obstructive Sleep-Disordered Breathing; PTH= post-tonsillectomy hemorrhage; SOE = strength of the evidence; RCT = Randomized Controlled Trial

Applicability

Studies included in this review typically did not describe populations adequately, which makes applicability difficult to assess. As would be expected, studies addressing KQ1 (tonsillectomy in children with OSDB) and KQ2 (tonsillectomy in children with recurrent throat infection) specified surgical indication and generally provided greater characterization of study participants. Baseline severity of throat infection or OSDB varied across these studies as did definitions of "cure" or resolution of symptoms. Of note, the largest U.S.-based RCT addressing tonsillectomy vs. no surgery for children with OSDB included a majority African-American and majority overweight or obese population as did two additional studies addressing this comparison. Two other studies addressing this comparison included a majority of children with Down Syndrome or mucopolysaccharidoses or children under 2 years of age. Three RCTs addressing tonsillectomy vs. no surgery for recurrent throat infection explicitly included children

with mild to moderate baseline symptoms. Four larger studies addressing this comparison (2 studies reported in each paper) included majority White populations.

Studies addressing surgical approaches and peri- or post- operative medications typically did not specify surgical indications or included both children with OSDB or recurrent throat infections without stratifying analyses. Roughly a third of studies were conducted in less developed countries in which surgical techniques and procedures may vary from those used in the United States. Regardless of country of conduct, anesthetic approaches, analgesic agents and dosing, surgical expertise, and surgical and hemostatic techniques (including definitions of "partial tonsillectomy") varied widely across studies. Studies reporting weight or BMI typically did not address whether children were under- or over- weight for age at baseline, and few studies reported baseline comorbidities such as asthma or Down Syndrome; thus assessing applicability to these sub-populations is challenging. Most studies used subjective outcome measures or relied on caregiver- or child-completed diaries to assess longer term outcomes. Objective measures such as the AHI or other PSG parameters may not accurately reflect effects on the totality of symptoms associated with OSDB (e.g., behavioral issues, sleepiness, overall quality of life).

Despite these limitations to generalizability, findings reported here are likely widely applicable given the heterogeneous population of children without comorbidities who undergo tonsillectomy. Applicability of findings to children with Down Syndrome, craniofacial abnormalities, obesity, or under age 2 is limited. While studies included some children with these comorbidities or in the younger age range, few provided explicit analyses of these subgroups. Appendix G of the full report includes applicability tables for each KQ.

Limitations of the Comparative Effectiveness Review Process

We included studies published in English only and did not seek or include unpublished data. We also included only studies of perioperative NSAID, steroids, and anti-emetics to address KQ5. While this undoubtedly means that some medications are not included in this review, these drug classes comprise key agents used frequently in the perioperative period. Given heterogeneity in anesthetic regimens, surgical techniques, postoperative analgesia and medications, and patient populations themselves, as well as the few studies that addressed questions about the need for tonsillectomy compared with a non-surgical treatment, we were limited in our ability to stratify findings or identify potential subgroups that may respond more favorably to tonsillectomy or to supportive care.

Limitations of the Evidence Base

A relatively large number of studies have been published on tonsillectomy, including for OSDB and throat infections, but risk of bias is mixed, with fewer studies (32%) having low risk of bias. Furthermore, most available studies provided little to no clinical outcome data, focusing instead on intermediate outcomes and harms. Patient populations were generally poorly characterized, and little information was available on first-line treatment attempts prior to surgery. Very few studies focused on high risk or special populations at particular risk.

Particularly in studies intended to assess effects of tonsillectomy on throat infections, parents of severely affected children were noted to refuse randomization and cross over to surgery at high rates. Long-term effects are limited in the literature base, particularly regarding outcomes that include growth/development, sleep quality outcomes, and behavioral outcomes for children with OSDB. Exploration of demographics of patient populations more likely to be refractory to initial management strategies is also limited. It appears clear that throat infections decline in

children over time regardless of treatment group, but with high loss to followup, the relative contribution of this decline on apparent effectiveness is unknown.

A particular problem in the literature is a lack of full characterization of the patient population, particularly around clinically documented severity of both sleep-disordered breathing and throat infections. In the context of general lay expectations of the benefit of tonsillectomy, and common opinions that tonsillectomy is a "minor" surgery, it is possible that patients undergoing tonsillectomy may vary widely in the severity of their clinical states. Among those studies focused on throat infection that did characterize patients, most had low numbers of reported infections, and few reported culture-confirmed bacterial infections.

Of particular importance for this surgical topic is a complete assessment of potential harms, particularly bleeding rates, including bleeding that leads to further intervention. However, the degree and timing of bleeding was rarely defined or measured; thus outcomes can only be broadly defined in terms of primary versus secondary bleeding, readmissions, and reoperations, where reported. Similarly, in attempting to assess partial versus total tonsillectomy we note that partial tonsillectomy was rarely precisely specified, and these studies most often used different techniques for the partial and total tonsillectomy, thus introducing confounding that cannot be disentangled.

Implications for Clinical and Policy Decisionmaking

This review provides evidence for decisionmaking in the care of children who are potential candidates for tonsillectomy. Despite the large body of literature, evidence is inadequate to provide clear evidence for consistent, and long-term benefit either for OSDB or throat infection. Thus, individual decisionmaking needs to balance short term needs for relief of illness-related outcomes (including missing school and work) with the risks associated with surgery. In cases where families are choosing between surgery and CPAP for OSDB, evidence is insufficient to support a decision. Families with children in special subgroups, including those with Down syndrome, similarly cannot rely on scientific evidence for their decision. There is modestly more evidence in the literature on throat infection, but the benefit of surgery is in the short term and not maintained over the long term. This suggests that if families are able to manage their children's illnesses for a period of time, they may outgrow the propensity for infection and be able to avoid surgery. That said, decisions are clearly in the hands of families and their clinicians and should be made on an individual basis. Harms are rare and generally minor, and clinicians have information from this review with which to counsel their patients and families.

Similarly, benefits of specific approaches to tonsillectomy (either partial versus total or by surgical technique) provide little clear guidance for clinicians. Some evidence suggests that partial removal may speed time to recovery relative to total removal; however, indication and severity are clearly important considerations for a decision around what approach to use, in addition to willingness to risk a potential 6% rate of regrowth that could require further surgery.

Bleeding was low across all surgical instrumentation approaches, and no clear evidence exists for a superior approach. It is likely that familiarity with a technique and surgical skill have a role in driving outcomes.

Decisional dilemmas still exist regarding the perioperative use of medication and whether they speed postoperative return to normal diet and activity and reduce the need for post-tonsillectomy analgesia and rescue anti-emetic use. Clinical care would be improved by optimizing perioperative use of medication to improve outcomes. The literature base on this subject was insufficient to provide guidance on whether any perioperative medications reduce

time to normal diet or activity. However, there was low strength to evidence to suggest that a single dose of IV dexamethasone intraoperatively does reduce analgesic requirement in the PACU and up to 24h postoperatively. Evidence is mixed whether dexamethasone reduces the need for postoperative rescue anti-emetics. In contrast, clinicians can have some confidence that pre-emptive 5-HT receptor antagonists given intra-operatively do reduce the need for rescue anti-emetics post-tonsillectomy.

Research Gaps

Tonsillectomy is heavily researched, with far more data available to assess safety than efficacy. Despite the abundance of research, the literature is largely silent on the natural history that would provide a basis for the need for tonsillectomy in the long term. Indeed, it appears as though many young patients may outgrow the need for intervention, but more data are needed to describe this process and likelihood for parents and to describe population factors that may predict resolution.[15-17] Long-term data are needed in order for parents to weigh the benefits of surgery versus the reality of managing their child's condition as they wait for it to resolve. Future studies should take more care to characterize patient populations completely such that applicability can be much more specifically described and potential candidates for surgery or watchful waiting identified.

As new technologies for tonsillectomy emerge, as they continuously have over the last few decades, high quality research will continue to be needed to evaluate these technologies, both in terms of efficacy and safety. As we learn more about the deleterious effects of sleep apnea and detection rates increase, more refined and specific treatment algorithms will be in demand. Related to this issue, more data are needed on the use of CPAP in children as an initial modality; such data should address compliance and duration of use.

Future research should also address the current gaps in data surrounding treatment of special populations including very young children and children with relevant comorbidities such as obesity and neuromuscular disease. Further, concerns about perioperative and postoperative management persist, including over-narcotization and potential respiratory suppression. Better data regarding optimal medication regimens are essential, both in terms of symptomatic relief and minimizing iatrogenic harm.

Finally, relatively little data exist regarding predictable factors contributing to failure of tonsillectomy for primary management of OSDB and throat infections. A better understanding of these factors would allow for more specific patient selection.

Conclusions

Tonsillectomy can effect modest short-term improvement in sleep outcomes and reduction in throat infections compared with no surgery in children with OSDB or recurrent throat infections. Data on longer term results are lacking. This modest short-term improvement must be weighed against a relatively low risk of postoperative bleeding. Surgical technique had little bearing on either outcomes or bleeding risk. Perioperative use of dexamethasone and pre-emptive 5-HT receptor antagonist anti-emetics should be considered to improve pain and reduce vomiting in the immediate postoperative period. Little evidence addressed the use of postoperative medications for pain-related outcomes.

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Introduction

Background

Tonsillectomy or adenotonsillectomy ("tonsillectomy") is the most common surgery performed in the U.S. and represents more than 15 percent of all surgical procedures in children under the age of 15 years.[1] The primary indication for tonsillectomy has shifted over the last 20 years from recurrent throat infections to obstructive sleep-disordered breathing (OSDB) and obstructive sleep apnea (OSA).[2, 3] Widely variable national and small area tonsillectomy rates are well-documented. In their seminal study, Wennberg and Gittlesohn found rates of tonsillectomy varied almost 12-fold across adjacent counties in rural Vermont with similar populations.[4] Variation in rates continue despite improved evidence and dissemination about indications.[5]

Surgical Techniques

Table 1 categorizes common surgical techniques used for tonsillectomy. Choice of technique depends on patient factors including the surgical indication (e.g., recurrent infection, OSDB) and clinician practice patterns. All procedures are performed under general anesthesia. Hereafter, we use the term tonsillectomy to refer to removal of the tonsils alone, removal of tonsils and adenoids (adenotonsillectomy), and partial removal of the tonsils (tonsillotomy, partial tonsillectomy) using any surgical technique or approach.

Table 1. Commonly used surgical techniques or tools for tonsillectomy

Surgical Technique or Tool	Description
Cold dissection	Palatine tonsils dissected and removed from oropharynx using a scalpel, scissors or other non-powered means.
Electrocautery	Palatine tonsils dissected and removed from oropharynx using electrocautery (i.e., monopolar cautery, bipolar cautery).
Harmonic scalpel	Palatine tonsils dissected and removed from oropharynx using ultrasonic energized instrumentation.
Microdebridement	Palatine tonsils removed from oropharynx using a microdebrider, which suctions tonsillar tissue into a rotary blade, which morselizes and removes tissue. All or part of the tonsil can be removed with this technique.
Laser ablation	Palatine tonsils removed from oropharynx with handheld laser.
Coblation	Palatine tonsils dissected and removed from oropharynx using low-temperature irrigation radio frequency energy device.

Indications for Tonsillectomy

Tonsillectomy has two primary indications: recurrent tonsillitis and obstructive sleep disordered breathing (OSDB). Recurrent or severe tonsillitis has been defined as (1) five or more episodes of true tonsillitis a year; (2) symptoms for at least a year; and (3) episodes that are disabling and prevent normal functioning.[6] No gold standard diagnostic test exists to etiologically implicate or predictably attribute symptoms to tonsillitis. In fact, consensus is lacking on what symptoms attributable to tonsillitis are considered "disabling." Surrogates often used for tonsillitis include sore throat and pharyngitis. However, the degree to which either of these terms reflects true tonsillitis is not known. Bacterial pharyngitis can be diagnosed via rapid testing or culture. It is not possible, however, to determine whether the tonsil represents the infectious nidus or if the suspected pathogen represents normal bacterial flora for a particular child's pharynx.

Despite evidence to the contrary, clinicians sometimes treat sore throat empirically with antibiotics without objective testing.[7] Sore throat or pharyngitis may or may not have a tonsillar origin, and it is possible that many cases have alternative explanations. Nonetheless, many cases are termed "tonsillitis" without supportive documentation.[8] Frequency of infections is a metric of severity used to determine eligibility for tonsillectomy.[1, 9, 10] This criterion is fraught with complexity related to diagnostic variability and also to incomplete and inconsistent medical documentation. Thus, heterogeneity in diagnostic accuracy, establishment of severity, and frequency of infections complicates treatment decisions regarding tonsillectomy and the performance of comparative effectiveness of its treatments.[1, 9, 11, 12]

Currently, the most common indication for tonsillectomy is OSDB (i.e., breathing difficulties during sleep including OSA and upper airway resistance syndrome [UARS]). OSDB results from obstruction from or dynamic collapse due to upper airway soft tissue during sleep resulting in snoring, hypopnea, apnea, and restless sleep. Adenotonsillar hypertrophy can cause oropharyngeal crowding, thereby increasing the likelihood of symptomatic airway collapse during sleep. OSDB includes disorders ranging from simple snoring to OSA and can result in significant quality of life and health consequences. It has been associated with a five-point decrease in intelligence quotient (IQ), hypersomnolence, emotional lability, decreased attention, small stature, enuresis, cardiopulmonary morbidity, and missed school.[13] Evidence of the relationship is reinforced by the effectiveness of OSDB treatment in improving behavior, attention, quality of life, neurocognitive functioning, enuresis, parasomnias, and restless sleep, and reversal of associated cardiovascular sequelae.[14, 15] Moreover, OSDB occurs at especially high rates in subsets of children with developmental disorders and craniofacial syndromes, including Down Syndrome.

As in adults, the gold standard diagnostic test for OSA in children is polysomnography (PSG), which physiologically tests sleep architecture and efficiency. Treatment involves alleviating the inciting upper airway soft tissue obstruction or collapse. One method of primary treatment is continuous positive airway pressure (CPAP), which is a device worn over a child's nose and/or mouth that delivers continuous high pressure flow to the lungs, acting as a pneumatic stent to maintain upper airway patency during sleep. CPAP compliance is highly variable in children.[16-20] Other approaches including weight loss in overweight children, orthodontic devices to expand the palate, and allergy or anti-inflammatory medications are therefore advocated. However, since the most common culprit in children is tonsillar hypertrophy-related oropharyngeal obstruction, tonsillectomy is often used to establish an adequate airway.

Regardless of indication, age may affect tonsillectomy outcomes. In general, younger children tend to tolerate surgery better than older children and adults,[21, 22] but risk is increased with surgery in very young children (< 2 years) compared with older children. Tonsillectomy is not commonly performed in this very young age group. To date, there is little guidance regarding the comparative effectiveness of treating recurrent infection or OSDB in children less than 2 years of age. Furthermore, there may be a differential effect of obesity on OSDB, which may alter expectations and treatment efficacy and outcomes.

Tonsillectomy is painful and is associated with odynophagia (painful swallowing) and dysphagia (difficulty swallowing) that can make it difficult to return to normal diet or stay hydrated, and can be associated with postoperative hemorrhage, nausea and vomiting. To help minimize these concerns, clinicians may use perioperative antibiotics, steroids, anti-emetics, and pain medications (e.g., non-steroidal anti-inflammatory drugs [NSAIDs] and other analgesics). A 2012 Cochrane review examining the effect of perioperative systemic antibiotics on post-

tonsillectomy morbidity (pain, consumption of pain medications, secondary hemorrhage, fever, and return to normal diet) failed to find any clinically important impact of antibiotics in reducing pain, need for analgesia, or secondary post-tonsillectomy hemorrhage (PTH).[23] However, this analysis combined adult and pediatric trials; thus, the applicability to children alone is not clear. Furthermore, this review included only randomized controlled trials (RCTs). The role of perioperative anti-inflammatory medications (e.g., NSAIDs) and systemic steroids have been addressed in prior meta-analyses and reviews, with consistent findings of low risk of PTH and reduced morbidity (pain, time to return to normal diet and activity) associated with perioperative dexamethasone in children,[24-29] and less consistent findings regarding NSAIDs.[30, 31] Two systematic reviews reported no significant risk of PTH with perioperative NSAID use[31, 32] while one reported insufficient data to rule out risk.[30] One review also noted an increased PTH risk with postoperative NSAIDs.[31]

Thus, clinicians and parents need to know three key things: 1) what is the likelihood that the surgery will improve clinical outcomes around recurrent throat infections and sleep disorders; 2) what is the risk that the child will experience a harm, primarily PTH, with the surgery; and 3) if surgery is indicated, what approach, in terms of both surgical technique and perioperative medical care, has been demonstrated to optimize effectiveness and minimize harms? We address these questions by reviewing the comparative (primarily RCT) data for effectiveness on a specific set of outcomes and also searching a broader set of studies for harms data in order to estimate the rates of the most common and most severe harms, namely PTH, readmission, and reoperation. The results from this report will be widely applicable; however, lack of consistently reported modifier data (e.g., BMI, surgical indications) may limit its generalizability to every child.

Scope and Key Questions

Scope of Review

The current review addresses the comparative effectiveness and harms of tonsillectomy in children with the most common indications for the procedure, namely, OSDB and recurrent throat infections. The review, nominated by the American Academy of Otolaryngology - Head & Neck Surgery Foundation, addresses key decisional dilemmas identified by stakeholders and through our preliminary scan of the literature in a comprehensive manner. The review also includes Key Questions (KQ) to improve understanding of outcomes in subgroups such as very young children (1-2 years old), children with Down syndrome, and those who are overweight or obese.

Key Questions

We developed KQs in consultation with Key Informants and the Task Order Officer. KQs were posted for review to the AHRQ Effective Health Care website. We note that OSDB includes breathing difficulties during sleep as operationalized in each study, including obstructive sleep apnea and upper airway resistance syndrome. As noted, tonsillectomy includes tonsillectomy, partial tonsillectomy, and adenotonsillectomy. We also note that comparative effectiveness includes both the benefits and harms of interventions.

Questions were as follows:

KQ1. In children with obstructive sleep-disordered breathing (OSDB), what is the comparative effectiveness of tonsillectomy compared with continuous positive airway pressure (CPAP), or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1a. In children with OSDB and neuromuscular or craniofacial abnormalities, what is the comparative effectiveness of tonsillectomy compared with CPAP, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1b. In children with OSDB under age 3 years, what is the comparative effectiveness of tonsillectomy compared with watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1c. In children with OSDB and Down syndrome, what is the comparative effectiveness of tonsillectomy compared with CPAP, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ1d. In children with OSDB who are overweight or obese, what is the comparative effectiveness of tonsillectomy compared with CPAP, weight loss, or watchful waiting with supportive care (including pharmacologic treatment) to improve sleep outcomes, cognitive or behavioral outcomes, and health outcomes?

KQ2. Among children with recurrent throat infections, what is the comparative effectiveness, including harms, of tonsillectomy compared with watchful waiting with supportive care (including pharmacologic—antibiotic or non-antibiotic—treatments) on the number and severity of throat infections, quality of life, and health care utilization?

KQ3. Do benefits and harms differ between partial tonsillectomy and total tonsillectomy?

KQ4. Do benefits and harms differ by surgical technique (e.g., cautery, coblation)?

KQ5. What are the benefits and harms of adjunctive perioperative (i.e., preoperative, intraoperative, or in post-anesthesia care) pharmacologic agents intended to improve outcomes?

KQ6. What are the benefits and harms of postoperative (i.e., after discharge from post-anesthesia care and up to 10 days post-surgery) pharmacologic agents intended to reduce pain-related outcomes?

Table 2 outlines Population, Intervention, Comparator, Outcomes, Timing, and Setting (PICOTS) characteristics for each KQ.

Table 2. Population, intervention, comparator, outcome characteristics[*]

KQ	Population	Intervention[†]	Comparators	Outcomes
1	Children (3-18 years of age) with OSDB[**]	Tonsillectomy	-Continuous positive airway pressure (CPAP) -Pharmacologic treatment including anti-inflammatory medications, decongestants, allergy medication, antihistamines, nasal steroids, leukotriene inhibitors	Sleep outcomes -Apnea Hypopnea Index (AHI) -Sleep quality measures (Obstructive Sleep Apnea-18 [OSA-18], Clinical Assessment Score-15 [CAS-15]) -Pediatric Sleep Questionnaire (PSQ) -Modified Epworth Sleepiness Scale -Desaturation nadir -OSDB persistence Cognitive or behavioral outcomes -Validated measures of attention, irritability, and memory Health outcomes -Growth velocity (height, BMI for age) -Cardiopulmonary issues -Self or caregiver-reported enuresis -Health care utilization (number of clinician visits) Harms -Re-admission or ER visit or ICU admission for postoperative pain, dehydration, bleeding, or nausea and vomiting -Reoperation for primary or secondary bleeding -Velopharyngeal insufficiency -30-day mortality -Harms of comparator agents reported in studies with comparison groups
1a	Children (3-18 years of age) with OSDB and neuromuscular or craniofacial abnormalities	Tonsillectomy	See comparators above (KQ1)	See outcomes above (KQ1)
1b	Children under age 3 with OSDB	Tonsillectomy	See comparators above (KQ1)	See outcomes above (KQ1) Length of stay
1c	Children (3-18 years of age) with OSDB and Down syndrome	Tonsillectomy	See comparators above (KQ1)	See outcomes above (KQ1) Length of stay
1d	Children (3-18 years of age) with OSDB who are overweight or obese	Tonsillectomy	-CPAP -Weight loss -Pharmacologic treatment including anti-inflammatory medications, decongestants, allergy medication,	See outcomes above (KQ1)

KQ	Population	Intervention[T]	Comparators	Outcomes
			antihistamines, nasal steroids, leukotriene inhibitors	
2	Children (3-18 years) with recurrent throat infections	Tonsillectomy	-Antibiotics -Nonantibiotic pharmacologic treatments (e.g., anti-inflammatory agents, decongestants, antihistamines, leukotriene inhibitors, nasal or systemic steroids)	Throat infections -Number of throat infections/year -Severity of throat infections -Number of streptococcal infections/year Quality of life -Validated quality of life measures -Missed school or work for child or caregiver Other outcomes -Health care utilization (number of clinician visits, number of courses of antibiotics) Harms - ER visit or hospital or ICU admission for postoperative pain, bleeding, dehydration, or nausea and vomiting -Reoperation for primary or secondary bleeding -Velopharyngeal insufficiency -30-day mortality -Harms of comparator agents reported in studies with comparison groups
3	Children (3-18 years) undergoing tonsillectomy	Total tonsillectomy	-Partial tonsillectomy	See sleep, cognitive or behavioral, and health outcomes (KQ1) and quality of life outcomes (KQ2) Throat infections -Number of throat infections/year -Severity of throat infections -Number of streptococcal infections/year Other outcomes -Symptomatic tonsillar regrowth -Time to return to usual activity (diet, school) Harms See KQ1 Reoperation for complete tonsillectomy
4	Children (3-18 years) undergoing tonsillectomy	Tonsillectomy	-Other technique for tonsillectomy	See sleep, cognitive or behavioral, and health outcomes (KQ1) and quality of life outcomes (KQ2) Throat infections -Number of throat infections/year -Severity of throat infections -Number of streptococcal infections/year Other outcomes

KQ	Population	Intervention†	Comparators	Outcomes
				-Time to return to usual activity (diet, school) Harms See KQ1
5	Children (3-18 years) undergoing tonsillectomy	Tonsillectomy plus adjunctive perioperative (i.e., preoperative, intraoperative, or immediate postoperative [post-anesthesia care] periods) pharmacologic agents	-Tonsillectomy without adjunctive perioperative pharmacologic agents (i.e., pharmacologic agents given to attempt to reduce postoperative morbidity including pain or nausea and vomiting)	-Pain management (need for rescue medications) -Time to return to usual activities (diet, school) -Health care utilization (number of clinician visits, number of courses of antibiotics) Harms -Harms of agent -Re-admission to hospital or ICU or ER visit for postoperative pain, bleeding, dehydration, or nausea and vomiting -Reoperation for primary or secondary bleeding -30-day mortality
6	Children (3-18 years) undergoing tonsillectomy and receiving pharmacologic agents for pain postoperatively (i.e., up to 10 days after discharge from post-anesthesia care)	Tonsillectomy plus postoperative pharmacologic agents for pain (e.g., NSAID, ketorolac)	-Tonsillectomy with other postoperative pharmacologic agents for pain	See outcomes and harms for KQ5

*Studies of any length or follow-up and in any setting, except for KQ6, which includes pharmacologic agents for pain given up to 10 days post-surgery.
**Includes breathing difficulties during sleep as operationalized in each study, including obstructive sleep apnea and upper airway resistance syndrome
†Tonsillectomy includes tonsillectomy, adenotonsillectomy, partial tonsillectomy
Abbreviations: AHI = Apnea Hypopnea Index; BMI = Body Mass Index; CAS-15 = Clinical Assessment Score-15; CPAP = Continuous Positive Airway Pressure; ER = Emergency Room; KQ = Key Question; NSAID = Non-steroidal Anti-Inflammatory Drug; OSA-18 = Obstructive Sleep Apnea-18; OSDB = Obstructive Sleep-Disordered Breathing

Analytic Framework

The analytic frameworks illustrate the population, interventions, and outcomes that guided the literature search and synthesis (Appendix A). The frameworks depict the key questions within the context of the population, intervention, comparator, outcomes, timing, and setting (PICOTS) parameters described in Table 2. In general, the figures illustrate how tonsillectomy may result in outcomes such as changes in sleep parameters, numbers of throat infections, quality of life, or health care utilization and how use of perioperative or postoperative medications may affect need for rescue medications and outcomes such as return to normal diet. The frameworks note that adverse events may occur at any point after intervention is received.

Organization of This Report

The Methods section describes the review processes including search strategy, inclusion and exclusion criteria, approach to review of abstracts and full publications, methods for extraction of data, and compiling evidence. We also describe our approach to grading the quality of the literature and describing the strength of the body of evidence.

The Results section presents the findings of the literature search and the review of the evidence by key question, synthesizing the findings across strategies. We present findings for each key question organized by intervention and outcome area where possible. We discuss harms reported in studies of surgical techniques in a separate section following discussion of effectiveness outcomes in each KQ, including a meta-analysis that provides expected rates of post-tonsillectomy hemorrhage by surgical approach and by partial versus total tonsillectomy. Summary tables for each key question outline key outcomes.

The Discussion section of the report discusses the results and expands on methodologic considerations relevant to each key question. We also outline the current state of the literature and challenges for future research in the field. The report includes a number of appendices to provide further detail on our methods and the studies assessed. The appendices are as follows:

- Appendix A: Analytic Frameworks
- Appendix B: Search Strategies
- Appendix C: Screening and Quality Assessment Forms
- Appendix D: Excluded Studies
- Appendix E: Meta-Analysis Methods
- Appendix F: Risk of Bias Ratings
- Appendix G: Applicability Tables
- Appendix H: Detailed Tables of Findings
- Appendix I: Summary of Recent Relevant Systematic Reviews and Meta-Analyses

We also provide a list of abbreviations and acronyms at the end of the report.

Uses of This Evidence Report

We anticipate this report will be of primary value to organizations that develop guidelines for tonsillectomy, to clinicians who provide care for children with indications for tonsillectomy, and for families making treatment decisions. Children who are candidates for tonsillectomy may be treated by clinicians including pediatricians, otolaryngologists, sleep medicine physicians, allergists, family physicians, anesthesiologists, infectious disease physicians, nurse-practitioners, physician assistants, and nurses. This report supplies practitioners and researchers up-to-date information about the current state of evidence and assesses the quality of studies that aim to determine the outcomes and safety of tonsillectomy.

Methods

In this chapter, we document the procedures that we used to produce a comparative effectiveness review (CER) on tonsillectomy in children with obstructive sleep-disordered breathing (OSDB) or recurrent throat infections. These procedures follow the methods outlined in the Agency for Healthcare Research and Quality (AHRQ) Effective Health Care Program *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[33]

Topic Refinement and Review Protocol

The topic for this report was nominated by the American Academy of Otolaryngology-Head and Neck Surgery in a public process using the Effective Health Care website. Working from the nomination, we drafted the initial key questions (KQ) and analytic framework and refined them with input from key informants representing the fields of pediatrics, otolaryngology, anesthesiology, and sleep medicine. We also spoke with a patient representative. All members of the research team were required to submit information about potential conflicts of interest before initiation of the work. No members of the review team had any conflicts.

After review from AHRQ, the questions and framework were posted online for public comment. No changes to the questions or framework were recommended. We also developed population, interventions, outcomes, timing, and settings (PICOTS) criteria for intervention KQ.

We identified technical experts on the topic to provide assistance during the project. The Technical Expert Panel (TEP), representing the fields of pediatrics, otolaryngology, anesthesiology, infectious disease, and sleep medicine, contributed to the AHRQ's broader goals of (1) creating and maintaining science partnerships as well as public-private partnerships and (2) meeting the needs of an array of potential users of its products. Thus, the TEP was both an additional resource and a sounding board during the project. The TEP included eight members serving as technical or clinical experts. To ensure robust, scientifically relevant work, TEP members participated in conference calls and discussions through e-mail to:

- Help to refine the analytic framework and KQ at the beginning of the project;
- Discuss inclusion/exclusion criteria; and
- Assist with determining key interventions and outcomes of interest.

The final protocol was posted to the AHRQ Effective Health Care web site and registered in the PROSPERO international register of systematic reviews (ID#: CRD42015025600).

Literature Search Strategy

Search Strategy

To ensure comprehensive retrieval of relevant studies of therapies for children undergoing tonsillectomy, we used three key databases: the MEDLINE® medical literature database via the PubMed® interface; EMBASE (Excerpta Medica Database), an international biomedical and pharmacological literature database via the Ovid® interface; and the Cochrane Library. Search strategies for KQs applied a combination of controlled vocabulary (Medical Subject Headings [MeSH] and Emtree headings) to focus specifically on tonsillectomy and harms of interventions. We restricted literature searches for KQs to studies published from 1980 to the present to reflect current techniques for tonsillectomy and perioperative or postoperative medications.

We only included studies published in English as a review of non-English citations retrieved by our MEDLINE search identified few studies of relevance. Appendix B lists our search terms and strategies and the yield from each database. Searches were last executed in August 2015.

We carried out hand searches of the reference lists of recent systematic reviews or meta-analyses of studies addressing pediatric tonsillectomy. The investigative team also scanned the reference lists of studies included after the full-text review phase for additional studies that potentially could meet our inclusion criteria.

Gray Literature

AHRQ's Scientific Resource Center requested Scientific Information Packets (SIPs) from companies that produce surgical instruments used for tonsillectomy or devices such as continuous positive airway pressure (CPAP) machines. Because many manufacturers may produce medications used in the peri- or postoperative periods, a notice of the opportunity to submit scientific material to inform the review was posted in the Federal Register for 6 weeks.

We also searched ClinicalTrials.gov to assess reporting bias and to identify any study results that may not have been identified in our other database searches. We applied the inclusion criteria in Table 4 to studies identified via our gray literature searches.

Inclusion and Exclusion Criteria

Table 3 lists the inclusion/exclusion criteria we used based on our understanding of the literature, key informant and public comment during the topic refinement phase, input from the TEP, and established principles of systematic review methods. We used a best evidence approach to determine final inclusion of studies (i.e., If evidence from randomized studies was insufficient to address a KQ or specific outcomes, we considered evidence from observational literature as well as factors related to the relevance of studies to determine if the inclusion of additional studies was warranted).[34] We also excluded studies considered to have high risk of bias (as described below) from analyses but conducted sensitivity analyses to gauge their effects on our findings.

We limited our searches for comparative effectiveness questions to studies published in English and from 1980 to the present for studies of the effectiveness of tonsillectomy in children with OSDB or recurrent throat infections (KQs 1-2). In consultation with the review nominator, we limited inclusion of studies relevant to KQs 3-6 to those published between 2000 and the present as we identified a large literature base, including many randomized controlled trials (RCTs), addressing these questions.

We also excluded studies including both children and adults if the mean plus standard deviation age of participants was greater than 18 years and data were not reported separately for children (3-18 years of age for most KQ). We included comparative studies (studies including an intervention and a comparison group) evaluating the benefits or harms of tonsillectomy (tonsillectomy, adenotonsillectomy, and partial tonsillectomy conducted using any surgical technique such as cautery or cold dissection) compared with an inactive control or alternate intervention. We also included case series or database studies including at least 1000 children undergoing tonsillectomy to address harms but not effectiveness. We selected the bound of 1000 as a conservative value based on a preliminary review in which we identified numerous case series or database studies with 1000 or more participants.

Table 3. Inclusion criteria for studies of tonsillectomy

Category	Criteria
Population	• Children with OSDB age 3-18 years, inclusive (KQ1) • Children with neuromuscular or craniofacial abnormalities and OSDB age 3-18 years, inclusive (KQ1a) • Children under age 3 years with OSDB (KQ1b) • Children with Down syndrome OSDB age 3-18 years, inclusive (KQ1c) • Children with obesity or overweight and OSDB age 3-18 years, inclusive (KQ1d) • Children with recurrent throat infection age 3-18 years, inclusive (KQ2) • Children with OSDB or recurrent throat infection undergoing tonsillectomy age 3-18 years, inclusive (KQ 4-6)
Intervention	• Tonsillectomy, adenotonsillectomy, or tonsillotomy (partial removal of tonsil) using any surgical approach (e.g., coblation, laser, cold dissection) (KQ 1-6) • Perioperative (preoperative, intraoperative, and immediate postoperative [post-anesthesia care] periods) NSAIDs, steroids, or anti-emetics (KQ5) • Any postoperative (discharge from post-anesthesia care to up to 10 days post-surgery) agent for pain (KQ6)
Design	• Effectiveness outcomes: Comparative studies (RCTs, prospective or retrospective cohort studies with comparison groups, nonrandomized trials, case-control studies) (KQ1-6) • Harms: Comparative studies (RCTs, prospective or retrospective cohort studies with comparison groups, nonrandomized trials, case-control studies), database or registry studies (harms of tonsillectomy), case series with at least 1000 participants (harms of tonsillectomy)
Other	• Original research (KQ1-6) • Publication language: English (KQ1-6) • Publication year: 1980-present (KQ1-2) or 2000-present (KQ3-6) • Reports one or more of the outcomes described in Table 2 • Sufficiently detailed methods and results to enable data extraction (KQ1-6) • Reports outcome data by target population or intervention (KQ1-KQ6) • Study assessed as low or moderate risk of bias

Abbreviations: KQ = Key Question; NSAID = non-steroidal anti-inflammatory drug; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Study Selection

Once we identified articles through the electronic database searches and hand-searching, we examined abstracts of articles to determine whether studies met our criteria. Two reviewers separately evaluated the abstracts of studies identified in our searches for Key Questions for inclusion or exclusion, using an Abstract Review Form (Appendix C). If one reviewer concluded that the article could be eligible for the review based on the abstract, we retained it. Following abstract review, two reviewers independently assessed the full text of each included study using a standardized form (Appendix C) that included questions stemming from our inclusion and exclusion criteria. A senior reviewer resolved disagreements between reviewers.

We conducted all abstract and full text reviews using the DistillerSR online screening application (Evidence Partners Incorporated, Ottawa, Ontario). Appendix D includes a list of excluded studies and the reasons for exclusion. Data extracted for each study are available via the Systematic Review Data Repository (http://srdr.ahrq.gov/).

Data Extraction

The staff members and clinical experts (including two otolaryngologists, one pediatrician, one pediatric pulmonology sleep medicine physician, one biostatistician, and three epidemiologists/systematic reviewers) who conducted this review jointly developed the data extraction forms for the KQs. We designed forms to provide sufficient information to enable

readers to understand the studies and to determine their quality; we gave particular emphasis to essential information related to the KQs. We used two templates to facilitate the extraction of data based on study type; one form was designed for case series or database studies that reported harms data and one to accommodate all types of comparative studies for effectiveness and harms data.

The team was trained to extract data by extracting several articles into the template and then reconvening as a group to discuss the utility of the template. We repeated this process through several iterations until we decided that the templates included the appropriate categories for gathering the information contained in the articles and for potential meta-analyses. Team data extractors shared the task of initially entering information into the evidence tables. A second team member also reviewed the articles and edited all initial entries for accuracy, completeness, and consistency. A senior reviewer reconciled disagreements concerning the information reported.

The full research team met regularly during the article extraction period and discussed issues related to the data extraction process. In addition to outcomes related to the effectiveness of tonsillectomy (e.g., changes in sleep parameters or quality of life), we extracted all data available on harms. Harms encompass the full range of specific negative effects, including the narrower definition of adverse events.

Data Synthesis

We summarized data for Key Questions qualitatively using summary tables where meta-analyses were not possible. We used a "best evidence" approach and focused on lower risk of bias studies where they provided sufficient data to address a KQ.[34] We identified sufficient data to address post-tonsillectomy bleeding and bleeding-related readmissions or clinician visits using quantitative meta-analysis methods. We implemented a mixed-effects, arm-based meta-analysis to assess the influence of different surgical procedures as well as the effect of partial compared with full tonsillectomy on the occurrence of bleeding outcomes following surgery. The occurrence of bleeding events in most studies were reported as counts, and can therefore be modeled as a binomial response, with inference derived from estimates of the probability of a bleeding event.

$$x_{ki} \sim \text{Binomial}(n_i, \pi_{ki})$$

where π_{ki} is the probability of a bleeding event for intervention k for study i. This probability is modeled hierarchically as a logit-linear model with treatment effects and a study-specific random effect as follows:

$$\text{logit}(p_{ki}) = \theta_k + \beta I(\text{partial}_k) + \alpha I(\text{high RoB}_i) + \epsilon_i$$

here, θ_k is a surgery-specific mean and β the effect of a partial removal when partial_k is true, while ϵ_i and α_i are a study random effect and a high risk of bias effect, respectively, that correspond to study i. Logit-linear model parameters were given zero-mean normal priors with $\sigma = 5$, which correspond to diffuse information when transformed to the inverse-logit scale. The study random effect was assumed normally distributed with an unknown standard deviation that was estimated from data, with a broad half-Cauchy prior distribution. This model was fit to each of four bleeding outcome data: re-operation bleeding, re-admission bleeding, primary bleeding, and secondary bleeding. None of the models showed evidence for lack of convergence or fit using our critera.[35, 36] We also conducted analyses to estimate the effects of including high risk of

bias studies in the analyses. These analyses suggested no systematic effects of these studies; thus we retained them. Appendix E contains a full description of the meta-analytic methods.

Risk of Bias Assessment of Individual Studies

We used separate tools appropriate for specific study designs to assess quality of individual studies meeting eligibility criteria for our KQs. We used prespecified questions from *Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions*[37] appropriate to each study design to assess risk of bias of RCTs and observational studies and a tool adapted from questions outlined in McMaster McHarms tool to assess reporting of harms.[38]

Questions assessing risk of bias evaluate domains including selection bias, performance bias, attrition bias, detection bias, and reporting bias as well as methods for recruiting cohorts and controlling for confounding. The harms assessment tool addresses questions related to pre-specification and reporting of harms.

Risk of bias assessment of each study was conducted independently by two team members using the forms presented in Appendix C. Any discrepancies were adjudicated by the two team members or a senior investigator. Investigators did not rely on the study design as described by authors of individual papers; rather, the methods section of each paper was reviewed to determine which rating tool to employ. The results of these tools were then translated to "low," "moderate," and "high" risk of bias ratings as described below. Appendix F reports risk of bias scoring for each study.

Determining Overall Risk of Bias Ratings

- We required that RCTs receive a positive rating (i.e., low risk of bias) on 12 of 13 of the questions used to assess each study to be considered to have low risk of bias. RCTs had to receive nine to eleven positive ratings to have moderate risk of bias, and studies with ≤ eight positive ratings were considered to have high risk of bias. We considered a rating of "unclear" for a question as a negative rating. We assessed the risk of bias for each major outcome of relevance reported but report an overall assessment unless the risk of bias varied by outcome.
- We required that cohort studies receive positive ratings on at least 13 of the 14 questions used to assess each study to have low risk of bias for cohort studies and on nine to 12 questions to be considered to have moderate risk of bias for cohort studies. We considered studies that received positive ratings on ≤ eight questions to have high risk of bias.
- We required that studies assessed for harms reporting receive positive ratings on all four of the four questions used to assess each study to be considered to have low risk of bias. We considered studies receiving three positive ratings as moderate risk of bias and those with two or fewer positive ratings as high risk of bias.

Strength of the Body of Evidence

We applied explicit criteria for rating the overall strength of the evidence for each key intervention-outcome pair for which the overall risk of bias was not high. We rated the strength of the evidence for the outcomes of interest for our Key Questions (Table 2) and for clinically important harms. We used established concepts of the quantity of evidence (e.g., numbers of studies, aggregate ending-sample sizes), the quality of evidence (from the risk of bias ratings on individual articles), and the coherence or consistency of findings across similar and dissimilar studies and in comparison to known or theoretically sound ideas of clinical knowledge.

The strength of evidence evaluation that we used is described in the Effective Health Care Program's *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*[33] and in the updated strength of evidence guide,[39] which emphasizes five major domains: study limitations (low, medium, high level of limitation), consistency (inconsistency not present, inconsistency present, unknown or not applicable), directness (direct, indirect), precision (precise, imprecise), and reporting bias. Study limitations are derived from the risk of bias assessment of the individual studies that addressed the KQs and specific outcome under consideration. Each key outcome for each comparison of interest is given an overall evidence grade based on the ratings for the individual domains.

We graded the overall strength of evidence as outlined in Table 3. Two senior staff members independently graded the body of evidence; disagreements were resolved as needed through discussion or third-party adjudication. We recorded strength of evidence assessments in tables, summarizing results for each outcome. We did not consider case series and database studies in the assessment of strength of the evidence for harms.

Table 3. Strength of evidence grades and definitions*

Grade	Definition
High	**We are very confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has few or no deficiencies. We believe that the findings are stable, i.e., another study would not change the conclusions.
Moderate	**We are moderately confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	**We have limited confidence that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	**We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome**. No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

* Excerpted from Berkman et al. 2014[39]

Applicability

We assessed the applicability of findings reported in the included literature addressing our KQs to the general population of children undergoing tonsillectomy by determining the population, intervention, comparator, and setting in each study and developing an overview of these elements for each intervention category. We anticipated that areas in which applicability would be especially important to describe would include the indication for tonsillectomy, age at treatment, surgical technique, and population characteristics such as BMI, Down syndrome, or craniofacial abnormalities. Applicability tables for each KQ are in Appendix G.

Peer Review and Public Commentary

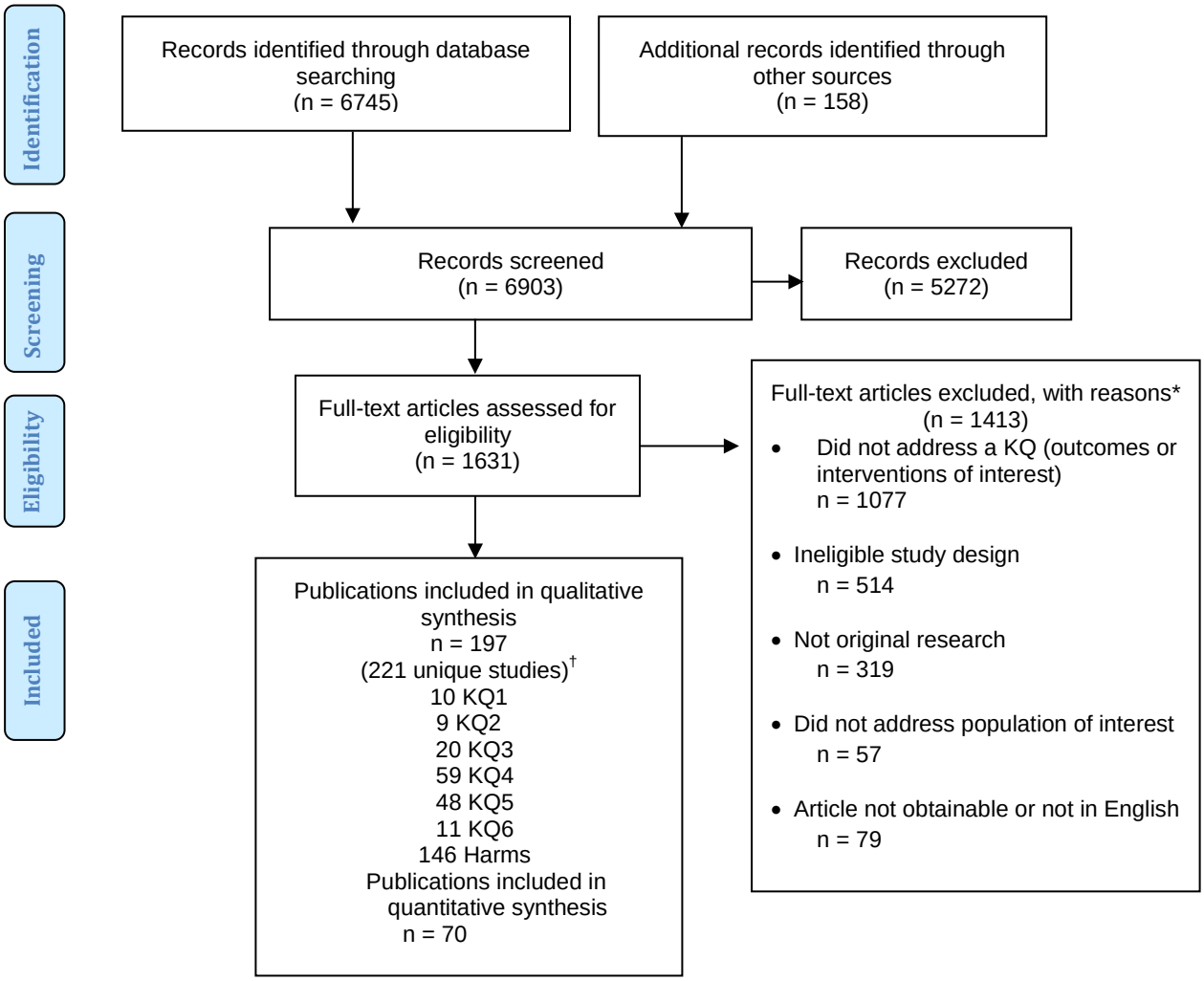
Researchers and clinicians with expertise in tonsillectomy and individuals representing stakeholder and user communities will provide external peer review of this report. The draft report will be posted on the AHRQ Web site for 4 weeks to elicit public comment. We will address all reviewer comments, revise the text as appropriate, and document changes and revisions to the report in a disposition of comments report that will be made available 3 months after AHRQ posts the final review on the AHRQ Web site.

Results

Results of Literature Searches for Key Questions

We identified 6903 nonduplicative titles or abstracts with potential relevance, with 1631 proceeding to full text review (Figure 1). We excluded 1414 studies at full text review. We included 197 unique studies (220 publications) in the review. These 197 studies included 156 comparative studies and 41 case series or database or registry studies providing data on harms only.

Figure 1. Disposition of studies identified for this review



†3 papers each reported 2 unique studies in each paper; thus, the total number of publications=221. Numbers next to each Key Question indicate number of unique studies addressing the question. Studies could address more than one Key Question.
*Numbers do not tally as studies could be excluded for multiple reasons.
Abbreviations: KQ = key question; n = number.

Description of Included Studies

The 197 unique included studies (reported in multiple publications) comprised 136 randomized controlled trials (RCTs),[9, 11, 40-188]10 nonrandomized trials,[11, 181, 189-196]

six prospective[197-202] and four retrospective cohort studies,[203-206] 18 database or registry studies,[21, 207-230] and 23 case series including ≥ 1000 children (Table 4).[231-254]We used database and registry studies and case series for harms data only. We considered 63 studies to have low risk of bias,[21, 41-43, 45, 51-56, 58, 59, 61, 71, 72, 77, 78, 90-92, 95, 96, 99, 100, 107, 114, 115, 117, 120-122, 125, 127, 130, 133-138, 146, 148, 153, 157, 158, 165, 169-172, 191, 201, 208-210, 214, 216-230] 102 to have moderate risk,[9, 40, 44, 46-50, 60, 62, 64-66, 68, 73, 74, 76, 80-82, 84-89, 93, 94, 97, 98, 105, 108, 109, 111-113, 116, 118, 119, 123, 124, 126, 128, 129, 132, 140, 141, 143, 144, 147, 149-152, 154, 156, 159-163, 166, 168, 173-190, 192-194, 196, 197, 200, 203, 204, 206, 211-213, 215, 231, 233-236, 239-248, 250-255] and 32 to have high risk.[11, 57, 63, 67, 69, 70, 75, 79, 83, 101-104, 106, 110, 131, 139, 142, 145, 155, 164, 195, 198, 199, 202, 205, 207, 232, 237, 238, 249]

Studies were conducted globally (Table 4), with most conducted in the United States (n=47, including 4 unique studies published in 2 papers),[9, 11, 21, 49, 56, 68, 70, 72, 79, 87, 92, 94, 95, 97, 99-101, 109, 110, 112, 114, 116, 118, 122, 124, 126, 128, 132, 153, 173-180, 204-206, 208, 211, 213, 215, 219, 223, 224, 229, 230, 232, 241, 243, 245, 254] United Kingdom (n=21, including 2 unique studies reported in one paper),[58, 77, 104, 105, 125, 127, 133, 136, 181, 203, 207, 209, 210, 217, 218, 220-222, 231, 233, 242, 247, 250] Turkey (n=19),[47, 50, 63, 67, 69, 75, 78, 82, 86, 103, 106-108, 115, 123, 141, 145, 190, 191] and Egypt (n=12).[42, 44, 53, 54, 102, 121, 144, 154, 160, 161, 165, 192] Sixty-five studies were conducted in developing or emerging nations (including, among others, Turkey, Egypt, Iran, Pakistan, Brazil, India, and China) according to United Nations classification.[256] [41, 42, 44, 46-48, 50, 52-54, 57, 63-65, 67, 69, 73-75, 78, 81, 82, 86, 89, 93, 102, 103, 106-108, 111, 115, 119, 121, 123, 141-146, 148-151, 154, 156, 158-165, 190-192, 196, 198-200, 202, 249, 251] Ages of children in studies ranged widely from less than 1 to over 18 (mean age ≤ 18 in all studies), and studies included a total of 1,329,429 children. Most studies did not specify an indication for tonsillectomy (n=79);[40, 41, 44, 48, 49, 51, 52, 66, 74, 75, 77, 78, 81, 89, 90, 94-96, 102, 105, 107, 108, 111, 114, 115, 117, 119-121, 123-125, 128-130, 134, 135, 137-140, 142, 143, 148-152, 155, 156, 158-161, 163, 169, 170, 195, 201, 207-211, 215-219, 225, 226, 229, 230, 235, 239-243, 246, 247, 250, 251] 60 studies included children with both obstructive sleep-disordered breathing (OSDB) and throat infections;[9, 21, 43, 45, 50, 56, 59, 61-64, 67, 68, 70-72, 76, 80, 83-85, 91, 98, 101, 104, 106, 110, 112, 113, 118, 122, 132, 133, 136, 146, 147, 157, 164, 166-168, 171, 172, 184-186, 190, 191, 213, 214, 220-224, 231-234, 236-238, 244, 245, 248, 252-254] 36 specifically noted OSDB as the surgical indication;[46, 55, 60, 65, 69, 73, 79, 86-88, 92, 97, 99, 100, 103, 109, 116, 126, 131, 141, 145, 153, 162, 173-180, 187-189, 194, 197-200, 202, 204, 205, 212, 227, 228] and 22 specifically noted recurrent throat infections as the indication.[11, 42, 47, 53, 54, 57, 58, 82, 93, 127, 144, 154, 165, 181-183, 192, 193, 196, 203, 206, 249]

Table 4. Overview of studies addressing tonsillectomy in children

Characteristic	RCTs (n=136)	Nonrandomized trials (n=10)	Prospective Cohort Studies (n=6)	Retrospective Cohort Studies (n=4)	Database or registry studies (n=18)	Case series (n=23)	Total Literature
Key Question							
KQ1 and 1a-d	3	0	5	2	0	0	10
KQ2	5	2	0	2	0	0	9
KQ3	18	2	0	0	0	0	20
KQ4	53	4	1	0	0	0	58
KQ5	47	1	0	0	0	0	48
KQ6	10	1	0	0	0	0	11
Harms	94	9	1	1	18	23	146
Surgical Indication							
OSDB	25	2	5	2	2	0	36

Throat Infection	14	5	0	2	0	1	22
OSDB+Throat Infection	41	2	0	0	5	12	60
Not Specified	56	1	1	0	11	10	79
Region of Study Conduct							
Africa	11	1	0	0	0	0	12
Asia	52	4	2	0	1	3	62
Australia/New Zealand	6	0	1	0	0	2	9
Europe	33	4	1	1	9	10	58
North America	33	1	0	3	8	8	53
South America	1	0	2	0	0	0	3
Risk of Bias							
Low	48	1	1	0	13	0	63
Moderate	67	7	2	3	4	19	101
High	21	2	3	1	1	4	33
Total N participants	**17119**	**2711**	**447**	**14288**	**1214515**	**80344**	**1329424**

KQ = Key Question; N = Number; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Gray Literature

We did not receive any materials from Federal Register notices. We sought reports of study protocols identified in ClinicalTrials.gov and other registers to assess for reporting bias but identified very few trials (n=8). Our gray literature searches did not contribute additional studies not identified in our database searches.

Key Question 1. Effectiveness of Tonsillectomy vs. No Surgery for OSDB

Key Points

- Strength of the evidence is low for clinically significant improvement in AHI; low for a modest improvement in sleep-related quality of life; and low for no effect on negative behaviors with tonsillectomy compared with no surgery. Strength of the evidence is insufficient to assess effects on executive function or IQ.
- Strength of the evidence is insufficient to assess effects on AHI or sleep-related quality of life in studies assessing tonsillectomy compared with CPAP and in studies assessing these outcomes in sub-populations (KQ1a-d).
- In five studies of children with PSG-proven OSDB, respiratory parameters measured using the AHI improved more in children receiving tonsillectomy than those not undergoing surgery. Sleep-related quality of life and negative behaviors (e.g., anxiety, emotional lability) also improved significantly more in children who had tonsillectomy than those who did not. Changes in executive function were not significantly different between groups.
- Studies comparing tonsillectomy and CPAP had mixed results, with significant improvements in respiratory parameters in the tonsillectomy group in one study and no significant differences in a second; both studies were small and included a majority of children with comorbidities (Down Syndrome, mucopolysaccharidoses) or under 24 months old.

Overview of the Literature

We identified 10 unique studies (17 papers, 1021 participants) addressing tonsillectomy in children with OSDB (Table 5).[46, 116, 173, 174, 176-180, 197-200, 202, 204, 205] Most studies were conducted in the United States (n=4),[116, 173-178, 180, 204, 205] two in Brazil,[199, 257] two in Israel,[198, 200] and one each in Australia[197] and India.[46] Three studies were RCTs, including one multiple-publication study.[46, 116, 173-180] Five were prospective[197-200, 202] and two were retrospective cohort studies.[204, 205] Eight studies compared tonsillectomy to watchful waiting (which could have included supportive treatment with medications such as nasal steroids) or no surgery.[116, 173-180, 197-200, 202, 204] Two studies compared continuous positive airway pressure (CPAP) or oxygen with tonsillectomy.[46, 205] Participant ages ranged from less than 2 years to 14 years across studies. Studies frequently reported change in AHI and cognitive or behavioral outcomes.

We considered six studies to have moderate risk of bias[46, 116, 173-180, 197, 200, 204] and four to have high risk of bias.[198, 199, 202, 205] Given the relatively few studies addressing this question, we retained high risk of bias studies as part of the evidence base.

Table 5. Overview of studies addressing tonsillectomy in children with OSDB

Characteristic	RCTs	Prospective Cohort Studies	Retrospective Cohort Studies	Total Literature
Comparisons				
Watchful Waiting or No Surgery	2	5	1	8
CPAP	1	0	1	2
Surgical Indication				
OSDB	3	5	2	10
Effectiveness Outcomes Frequently Reported				
AHI	3	2	2	7
Sleep-related quality of life (OSA-18, M-ESS, PSQ)	2	0	1	3
Executive function, Cognitive, or Behavioral Measure	1	2	1	4
Risk of Bias				
Low	0	0	0	0
Moderate	3	2	1	6
High	0	3	1	4
Total N participants	**529**	**386**	**106**	**1021**

AHI = Apnea–Hypopnea Index; CPAP = Continuous Positive Airway Pressure; M-ESS = Modified Epworth Sleepiness Scale; N = Number; OSA-18 = Obstructive Sleep Apnea-18; OSDB = Obstructive Sleep-Disordered Breathing; PSQ = Pediatric Sleep Questionnaire; RCT = Randomized Controlled Trial

Detailed Analysis

Tonsillectomy vs. No Surgery or Watchful Waiting with Supportive Care

OSDB-Related Outcomes

Five studies (reported in multiple publications) of moderate[116, 173-180, 197, 198, 204] risk of bias evaluated the improvement in AHI among children with polysomnography (PSG)-proven OSDB. Two studies were RCTs, including the multi-publication Childhood Adenotonsillectomy Trial (CHAT);[116, 173-180] two were prospective[197, 198] and one was a retrospective cohort study,[204] All reported improvement in children after tonsillectomy compared with observation without intervention or with supportive/medical management (excluding CPAP). Differences between groups were statistically significant in two studies; not significant in two; and one study did not comment on significance. This benefit was consistent across age ranges (1-18 years), though data were most frequently available on children ages 4 to 12. (Table 6). Benefits seemed durable, with followup ranging from 6 months to 4 years. Where reported, the respiratory disturbance index and oxygen saturation improved significantly after tonsillectomy. Further, in a single, small low risk of bias study, tonsillectomy was associated with clinical benefit in symptoms of children with diagnoses of sleep apnea based on history, but with negative polysomnograms.[116] This study is quite small, however, with fewer than 40 participants.

A single retrospective cohort examined a mostly overweight/obese population with PSG-proven OSDB.[204] Though AHI decreased significantly in children who received tonsillectomy compared with those who did not, this one study is inadequate to conclude that obesity definitively modifies effectiveness of tonsillectomy. Another study with high risk of bias also noted less slow wave activity during sleep in children with OSA who were not treated compared with those that were.[198]

Table 6. Key OSDB-related outcomes in studies comparing tonsillectomy with watchful waiting in children with OSDB

Author, Year Study Type RoB	Comparison Groups (n)	Baseline (mean±SD)	Follow-Up (mean±SD)
Marcus 2014[173-179] RCT Moderate ROB	G1: Tonsillectomy (193) G2: Watchful Waiting with Supportive Care (208)	Events/hour, median (IQR) G1: 4.8 (2.7 to 8.8) G2: 4.5 (2.5 to 8.9)	Events/hour, change from baseline to 7 months (IQR) G1: -3.5 (-7.1 to -1.8) G2: -1.6 (-3.7 to 0.5) G1 vs. G2: p < 0.001 Effect size: 0.57
Biggs 2014[197] Prospective Cohort Moderate ROB	G1: Tonsillectomy or Nasal Steroids (12) G2: No treatment (27)	Events/hour G1: 9.4 ± 9.9 G2: 1.0 ± 1.2	Events/hour (4 year followup) G1: 1.8 ± 5.2 G2: 1.7 ± 6.0 G1 vs. G2: p=NS
Burstein 2013[204] Retrospective Cohort* Moderate ROB	G1: Tonsillectomy (16) G2: No Surgery (16)	G1: 14.4 (median) G2: 9.3 (median)	G1: 1.1 (median), median change=10.3 G2: 3.7 (median), median change=6.5 G1 vs. G2, median change: p=0.04

Ben-Israel 2011[198] Prospective Cohort High ROB	G1: Tonsillectomy (14) G2: No Surgery (6)	Events/hour G1: 10.0 ± 10.3 G2: 9.4 ± 7.6	19-month followup Events/hour G1: 1.1 ± 1.0 G2: 13.1 ± 7.7 G1 vs. G2: p= NR
Goldstein 2004[116] RCT Moderate ROB	G1: PSG+ plus Tonsillectomy (21) G2: PSG- plus Tonsillectomy (11) G3: PSG- plus Watchful Waiting (9)	G1: 6.2 (median) G2: 0.5 (median) G3: 0.6 (median)	6-month followup G1: 0.9 (median) G2: 0.4 (median) G3: 0 G2 vs. G3: p=NS

*Note: Followup periods differed in this study: mean 1.4 years in the tonsillectomy group and 2.0 years in the no surgery group, p=0.02[204] IQR = Interquartile Range; n = Number; OSDB = Obstructive Sleep-Disordered Breathing; PSG = Polysomnography; NR = Not Reported; NS = Not Significant; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Sleep-Related Quality of Life

Two moderate risk of RCTs[116, 173, 174, 176-180] and one retrospective cohort[204]rated as moderate risk of bias for that study type assessed comparative effectiveness of tonsillectomy versus no surgery in the improvement of sleep quality (Table 7). Studies used several different parent-reported quality measures to assess sleep quality outcomes, limiting the ability to compare effectiveness directly across studies, although outcomes were consistently better in children receiving tonsillectomy.

One RCT and the retrospective cohort used the CAS-15 (Clinical Assessment Score),[116, 204] and both reported significant reduction in scores in the tonsillectomy compared with no tonsillectomy groups, indicating improvement in sleep quality following tonsillectomy. The CHAT RCT used the Modified Epworth Sleepiness Scale (M-ESS) and OSA-18 as a measure of quality of life, with significant improvement in sleep quality reported in the tonsillectomy group vs. no surgery on both scales.[173, 174, 176-180] This RCT also used the Pediatric Sleep Questionnaire Sleep-related Breathing Disorder scale (PSQ-SRBD), which showed significant improvements in sleep quality after tonsillectomy versus watchful waiting. Finally, overall quality of life as measured by the Pediatric Quality of Life Inventory (PedsQL) improved significantly after tonsillectomy, compared with the untreated group in one RCT.[173, 174, 176-180, 197] Results for the benefit of tonsillectomy to improve sleep quality in children suffering from OSDB were positive across a number of outcomes and outcome domains. Many parents' chief complaint in bringing their child with OSDB to medical attention relates to impaired quality of life. Results were consistently positive for tonsillectomy relative to observation in short time frames, with limited data available in the longer term.

Table 7. Key sleep-related quality of life outcomes in studies comparing tonsillectomy and no surgery in children with OSDB

Author, Year Study Type Groups (N) RoB	Mean Age, Years±SD Comorbidities N (%)	Outcome Measure Baseline (mean±SD)	Outcome Measure Follow-Up (mean±SD)

Marcus 2014[173-179] RCT G1: Tonsillectomy (193) G2: Watchful Waiting with Supportive Care (208) Moderate ROB	G1: 6.5±1.4 years G2: 6.5±1.4 years Overweight or Obese G1: 93 (48) G2: 94 (46) Failure to Thrive G1: 4 (2) G2: 3 (1)	**OSA-18 Total Score** G1: 53.1 ± 18.3 G2: 54.1 ± 18.8 **PSQ** G1: 0.5 ± 0.2 G2: 0.5 ± 0.2 **M-ESS** G1: 7.1 ± 4.7 G2: 7.5 ± 5.2 **PedsQL** G1: 77.3 ± 15.3 G2: 76.5 ± 15.7	**OSA-18 Total Score, change from baseline** G1: -21 ±16.5 G2: -4.5 ± 19.3 G1 vs. G2: p≤0.01 Effect size:-0.93 **PSQ, change from baseline** G1: -0.3 ±0.2 G2: -0.0 ± 0.2 G1 vs. G2: p≤0.01 Effect size: -1.35 **M-ESS, change from baseline** G1: -2.01 ± 4.7 G2: 0.28 ± 4.1 G1 vs. G2: p < 0.01 Effect size: -0.42 **PedsQL, change from baseline to 7 months** G1: 5.9 ± 13.6 G2: 0.9 ± 13.3 G1 vs. G2: p≤0.001 Effect size: 0.37
Burstein 2013[204] Retrospective Cohort G1: Tonsillectomy (16) G2: No Surgery (16) Moderate ROB	G1: 6.1±3.3 G2: 6.6±3.0 Overweight or obese G1: 10 (63) G2: 14 (88)	**CAS-15** G1: NR G2: NR	**CAS-15** G1: 8.9 ± 6.1 G2: 29.4 ± 16.2 G1 vs. G2: p < 0.001
Goldstein 2004[116] RCT G1: PSG+ plus Tonsillectomy (21) G2: PSG- plus Tonsillectomy (11) G3: PSG- plus Watchful Waiting (9) Low ROB	G1: 7.0±3.6 years G2: 6.3±1.8 years G3: 5.8±2.6 years Comorbidities: NA	**CAS-15 (median)** G1: 77 G2: 64 G3: 50	**CAS-15 (median)** G1: 59 G2: 49 G3: 8 G2 vs. G3: p=0.001

CAS-15 = Clinical Assessment Score-15; M-ESS = Modified Epworth Sleepiness Scale; G = Group; N = Number; NA = Not Applicable; OSA-18 = Obstructive Sleep Apnea-18 ; PedsQL = Pediatric Quality of Life Inventory; PSG = Polysomnography; PSQ = Pediatric Sleep Questionnaire; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Behavioral Outcomes

The CHAT RCT[173-179] and one prospective[197] and one retrospective cohort study[204] addressed behavioral outcomes (Table 8). All studies had a moderate risk of bias and used different scales to assess outcomes, again limiting our ability to compare effectiveness directly across studies. Two studies used the Child Behavior Checklist (CBC) to measure internalizing (emotionally reactive, anxious/depressed, somatic complaints, withdrawn behavior) and externalizing

(attention problems and aggressive behavior) behaviors. Total problem scores on the scale reflect the sum of these domains, and lower scores equate to fewer behavioral problems. Scores on the CBC improved from baseline in both groups in one cohort study, with no significant group differences.[197] In the second study, scores were significantly better in the tonsillectomy compared with no tonsillectomy group at followup, but baseline measures were not reported.[204]

CHAT investigators used the Conners' rating scale to assess behavioral issues including emotional lability and reported significant improvements (i.e., lowering of scores) in the tonsillectomy arm compared with no tonsillectomy on both teacher and parent-reported scales.[173-179]

Table 8. Key OSDB-related behavioral outcomes in studies comparing tonsillectomy and no surgery in children with OSDB

Author, Year Study Type Groups (N) RoB	Comparison Groups (n)	Outcome Measure Baseline (mean±SD)	Outcome Measure Followup (mean±SD)
Marcus 2014[173-179] RCT Moderate ROB	G1: Tonsillectomy (193) G2: Watchful Waiting with Supportive Care (208)	**Conners' (CGI) caregiver** G1: 52.5 ± 11.6 G2: 52.6 ± 11.7 **Conners' (CGI) teacher** G1: 56.4 ± 14.4 G2: 55.1 ± 12.8	**Conners' (CGI) caregiver, change from baseline to 7 months** G1: -2.9 ± 9.9 G2: -0.2 ± 9.4 G1 vs. G2: p=0.01 **Conners' (CGI) teacher, change from baseline to 7 months** G1: -4.9 ± 12.9 G2: -1.5 ±10.7 G1 vs. G2: p=0.04
Biggs 2014[197] Prospective Cohort Moderate ROB	G1: Tonsillectomy or Nasal Steroids (12) G2: No treatment (27)	**CBC Total Problem** G1: 64 ± 9 G2: 59 ± 10	**CBC Total Problem (4 years post-tonsillectomy)** G1: 61 ± 15 G2: 57 ± 12 G1 vs. G2: p=NS
Burstein 2013[204] Retrospective Cohort Moderate ROB	G1: Tonsillectomy (16) G2: No Surgery (16)	**CBC Total Problem** G1: NR G2: NR	**CBC Total Problem (1.66-1.97 years post-tonsillectomy)** G1: 43.9 G2: 58.9 G1 vs. G2: p < 0.001

CBC = Child Behavior Checklist; CGI = Connors Global Index; G = Group; N = Number; NA = Not Applicable; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Executive Function

One RCT and one prospective cohort study used the Developmental NEuroPSYchological Assessment (NEPSY) to evaluate attention and the Behavior Rating Inventory of Executive Function (BRIEF) to assess behavioral regulation and meta-cognition (Table 9).[173-179, 197] In the RCT, scores on the NEPSY improved from baseline in both groups, but group differences were not significant. Global scores on the BRIEF improved significantly among treated children compared with untreated children when evaluated by caregivers.[173-179, 197]When BRIEF was completed by teachers in a single study, differences in groups were not significant.[173-179]

Table 9. Key OSDB-related executive function outcomes in studies comparing tonsillectomy and no surgery in children with OSDB

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
Marcus 2014[173, 174, 176-179] RCT Moderate ROB	G1: Adenotonsillectomy (193) G2: Watchful Waiting with Supportive Care, (208)	**NEPSY*** G1: 101.5 ± 15.9 G2: 101.1 ± 15 **BRIEF (GEC) caregiver** G1: 50.1 ± 11.2 G2: 50.1 ± 11.5 **BRIEF (GEC) teacher** G1: 57.2 ± 14.1 G2: 56.4 ± 11.7	**Change from baseline to 7 months** **NEPSY*** G1: 7.1 ± 13.9 G2: 5.1 ± 13.4 G1 vs. G2: p=NS Effect size: 0.15 **BRIEF (GEC) caregiver** G1: -3.3 ± 8.5 G2: 0.4 ± 8.8 G1 vs. G2: p < 0.001 Effect size: 0.28 **BRIEF (GEC) teacher** G1: -3.1 ± 12.6 G2: -1.0 ± 11.2 G1 vs. G2: p=NS Effect size: 0.18
Biggs 2014[197] Prospective Cohort Moderate ROB	G1: Tonsillectomy or Nasal Steroids (12) G2: No treatment (27)	**BRIEF (GEC)** G1: 62 ± 11 G2: 58 ± 11	**BRIEF (GEC) (4 years post-tonsillectomy)** G1: 58 ± 16 G2: 57 ± 12 G1 vs. G2: p < 0.05

BRIEF (GEC) = Behavior Rating Inventory of Executive Function (Global Executive Composite); G = Group; N = Number; NA = Not Applicable; NEPSY = Neuropsychological Assessment; NS = Not Significant; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation
*NEPSY attention and executive function

Cardiopulmonary and Physiologic Outcomes

One RCT reported in multiple publications[173-180] (moderate risk of bias) and three prospective cohort studies with moderate[200] and high[198, 202] risk of bias addressed outcomes including cardiometabolic measures. Children had PSG-proven OSDB in two studies.[198, 200] Evidence was insufficient to comment on physiologic parameters, with a single RCT reporting no change in cardiometabolic measures, including insulin, lipids, and C-reactive protein levels.[173, 174, 176-180] Underweight children showed a significant increase in weight and BMI in two studies.[173-180, 202]

Utilization and Other Outcomes

Two cohort studies with moderate risk of bias assessed health care utilization, defined as clinician contacts or antibiotic prescriptions, or cognitive outcomes (Table 10). A single moderate risk of bias cohort study reported a 33 percent reduction in gross health care utilization, including a 60 percent reduction in hospital admissions over one year following tonsillectomy in children with PSG-proven OSDB, while admissions in the untreated group increased (p=NR).[200]

One cohort study using the Weschler Abbreviated Scale of Intelligence reported a significant

improvement in performance IQ at 4-years post-tonsillectomy in children undergoing tonsillectomy, but both the tonsillectomy and no surgery groups had declines or no change in full scale IQ and verbal IQ over the same period.[197]

Table 10. Other outcomes in studies comparing tonsillectomy with watchful waiting in children with OSDB

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
Tarasiuk 2004[200] Prospective cohort Moderate RoB	G1: Tonsillectomy (130) G2: No tonsillectomy (90)	G1+G2: NR	**Number of new admissions, mean±standard error/patient/year** Year 1 G1: 0.15±0.04 G2: 0.08±0.03 Year 2 G1: 0.06±0.02 G2: 0.25±0.07 **Number of emergency department visits, mean±standard error/patient/year** Year 1 G1: 0.57±0.09 G2: 0.52±0.09 Year 2 G1: 0.35±0.05 G2: 0.37±0.10 **Number of consultations, mean±standard error/patient/year** Year 1 G1: 3.6±0.37 G2: 4.4±0.40 G1 vs. G2: p= NR Year 2 G1: 1.9±0.26 G2: 3.5±0.46 G1 vs. G2: p= NR
Biggs 2014[197] Prospective Cohort Moderate ROB	G1: Tonsillectomy (12) G2: No treatment (27)	**WASI Full Scale IQ** G1:102 ± 13 G2: 106 ±14	**WASI Full Scale IQ** G1: 101 ± 12 G2: 104 ± 15 G1 vs. G2: p=NS

G = Group; IQ = Intelligence Quotient; N = Number; NA = Not Applicable; NS = Not significant; ROB = Risk of Bias; SD = Standard Deviation; WASI = Wechsler Abbreviated Scale of Intelligence

Tonsillectomy vs. CPAP

OSDB-Related and Sleep Outcomes

One RCT[46] with moderate risk of bias and one retrospective cohort study[205] with high risk of bias addressed OSDB- and sleep-related outcomes in children with OSDB who received tonsillectomy compared with CPAP (Table 11). Children in the RCT had concomitant Down

Syndrome or mucopolysaccharidoses (n=32). Children receiving tonsillectomy had improved AHI scores compared with children receiving CPAP, but group differences were not significant in this small study.[46]More children in the tonsillectomy arm in the RCT had resolution of OSDB (defined as AHI < 1, 91.8% vs. 86.1%, p=NR). The RCT also evaluated sleep outcomes using the ESS and OSA-18. Both groups improved on these measures from baseline with no significant group differences.[46] Immediate improvement occurred on initiation with CPAP versus a gradual progression with tonsillectomy.

Although outcomes were reported to be superior in children receiving tonsillectomy in the cohort study, this was a high risk of bias, retrospective study, so can contribute little to our assessment of comparative effectiveness.[205]

Table 11. OSDB resolution and sleep outcomes in studies comparing tonsillectomy with CPAP

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline	Outcome Measure Followup
Sudarsan 2014[46] RCT Moderate ROB	G1: Tonsillectomy (37) G2: CPAP (36)	**AHI, mean±SD** G1: 3.83 ± 1.36 G2: 3.46 ± 0.87 **Sleep Outcomes OSA-18 Total Score, mean±SD** G1:116.97 ± 2.25 G2: 116.87 ± 1.3 **ESS-C** G1: 13.76 ± 1.32 G2: 14.44 ± 2.18	**AHI, mean±SD** G1: 1.06 ± 0.74 G2: 1.07 ± 0.57 G1 vs. G2: p=NS **Resolution rate** (resolution=AHI < 1), (%) G1: 91.8 G2: 86.1 G1 vs. G2: p= NR AHI < 1, % G1+G2: 89 **Sleep Outcomes OSA-18 Total Score, mean±SD** G1: 73.59 ± 4.14 G2: 75.02 ± 2.5 G1 vs. G2: p=NS **ESS-C** G1: 5.46 ± 1.35 G2: 7.86 ± 1.69 G1 vs. G2: p=NS
Brigance 2009[205] Retrospective Cohort High ROB	G1:Tonsillectomy (61) G2: CPAP or other treatment (12)	**AHI, mean** G1: 17.73 G2: 18.26	**AHI, mean** G1: 8.17 (mean change=9.6, 95% CI: 5.8 to 13.4) G2: 21.26 (mean change=-3.0, 95% CI: -15.1 to 9.1) Mean difference in AHI change scores: 12.56 (95% CI: 2.7 to 22.4), p=0.013

AHI = Apnea-Hypopnea Index; CI = Confidence Interval; CPAP = Continuous Positive Airway Pressure; ESS-C = Epworth Sleepiness Scale - Child ; G = Group; M-ESS = Modified Epworth Sleepiness Scale; N = Number; NR = Not Reported; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Key Question 1a. Effectiveness of Tonsillectomy for Children with OSDB and Neuromuscular or Craniofacial Abnormalities

Only a single RCT (moderate risk of bias) compared the efficacy of adenotonsillectomy to immediate initiation of CPAP in children with Down Syndrome and mucopolysaccharidoses who were diagnosed with obstructive sleep apnea by polysomnogram.[46] As discussed above, both groups showed improvement in AHI at 6-month follow-up, with maintenance at 12-month follow-up (no significant group differences). Within this study, three patients (8.1%) who underwent adenotonsillectomy had persistent symptoms of OSDB and five patients (13.8%) who initiated CPAP had persistent OSDB symptoms. Baseline mean AHI scores for children in this study were far higher than normative scores reported in healthy patient studies.

Key Question 1b. Effectiveness of Tonsillectomy for Children with OSDB Under 3 Years of Age

While several studies included children under 3, these data were not extractable from the aggregate data of the entire study population. Only a single high risk of bias retrospective cohort study[205] focused exclusively on younger children. The study included 73 children 2 years of age and younger and reported greater improvements in AHI in children receiving tonsillectomy compared with those receiving CPAP or other treatments. Limitations of this study include a very small medical management arm (n=12) and lack of generalizability, with 63/73 children having various significant comorbidities.

Key Question 1c. Effectiveness of Tonsillectomy for Children with OSDB and Down Syndrome

Only a single RCT (moderate risk of bias) specifically recruited children with Down Syndrome.[46] Data were reported along with children with mucopolysaccharidoses. This study is discussed in detail above.

Key Question 1d. Effectiveness of Tonsillectomy for Children with OSDB and Obesity

One retrospective cohort study examined a mostly overweight/obese population with PSG-proven OSDB.[204] As noted above, the study reported a significant improvement in AHI in children who received tonsillectomy compared with those who did not; however, data were insufficient to suggest effect modification by obesity/overweight status in this single, small study.

Key Question 2. Effectiveness of Tonsillectomy vs. No Surgery for Recurrent Throat Infection

Key Points

- Strength of the evidence is moderate for a modest reduction in throat infections or streptococcal infections in the short term (< 12 months) after tonsillectomy vs. no surgery

and insufficient for reduction of infections in the longer term. Strength of evidence is low for no difference in streptoccocal infection reduction in the longer term.

- Strength of evidence is low for reduction in utilization (clinician contacts) following tonsillectomy compared with no surgery in the short term; low for improvements in missed school in the short term; low for no difference in missed school over the longer term; and low for no differences in quality of life after tonsillectomy vs. no surgery.
- Overall, children undergoing tonsillectomy to improve number of throat infections, associated health care utilization, days of work/school missed, and quality of life had improvements in these outcomes in the first post-surgical year vs. children not receiving surgery, with diminishing benefits over time.
- Data on long-term outcomes of children with recurrent sore throat who do not undergo tonsillectomy are limited.

Overview of the Literature

We identified nine unique studies addressing tonsillectomy specifically for recurrent throat infections (Table 12).[9, 11, 166-168, 181-183, 203, 206] Four unique studies (3 RCTs and 1 nonrandomized trial) were reported in two papers,[9, 11] and one set of investigators reported RCT and nonrandomized trial results together in multiple papers.[181-183] Another RCT was reported in multiple papers.[166-168] Five studies were conducted in the United States,[9, 11, 206] three in the United Kingdom,[181-183, 203] and one in the Netherlands.[166-168]Studies included five RCTs,[9, 11, 166-168, 181-183] two nonrandomized trials,[11, 181-183] and two retrospective cohorts.[203, 206] Studies compared tonsillectomy to medical treatment including antibiotics or other conventional medical management[11, 181-183] or no surgery (which could have included supportive medical treatment).[9, 166-168, 203, 206] Studies included a total of 15683 participants (at time of randomization or the start of the study) ranging in age from 2 to 16 years. Outcomes reported in most studies included number of throat infections or streptococcal infections.

Four RCTs and one nonrandomized trial and two retrospective cohort studies had moderate risk of bias,[9, 166-168, 181-183, 203, 206] and one RCT and one nonrandomized trial had high risk of bias.[11] Given the relatively few studies addressing this question, we retained high risk of bias studies as part of the evidence base.

Table 12. Overview of studies addressing tonsillectomy in children with recurrent throat infections

Characteristic	RCTs	Nonrandomized Trials	Retrospective Cohort Studies	Total Literature
Comparisons				
No Surgery	3	0	2	5
Medical Treatment	2	2	0	4
Surgical Indication				
Throat Infection	2	2	2	6
OSDB+Throat Infection	3	0	0	3
Effectiveness Outcomes Frequently Reported				
Number Throat Infections	5	2	1	8

Number Streptococcal Infections	3	1	1	5
Utilization (# clinician consultations or antibiotic prescriptions)	1	1	1	3
Missed School or Work	4	1	0	5
Risk of Bias				
Low	0	0	0	0
Moderate	4	1	2	7
High	1	1	0	2
Total N participants	**944**	**557**	**14182**	**15683**

N = number; OSDB = obstructive sleep-disordered breathing; RCT = randomized controlled trial

Detailed Analysis

Tonsillectomy vs. No Surgery/Watchful Waiting

Five RCTs[9, 11, 166-168, 181-183] (including 2 reported in one publication[9] and 2 reported in multiple publications[166-168, 181-183]), two nonrandomized trials[11, 181-183] and two retrospective cohort studies[203, 206] reported on recurrent throat infections and clinician visits following surgery or no surgery (Tables 13-14). We considered four RCTs (including 2 published in one paper[9]) to have moderate risk of bias.[9, 166, 168, 181-183, 255] One RCT had high risk of bias,[10] as did one nonrandomized trial published in the same paper as the RCT.[10] Another nonrandomized trial had moderate risk of bias.[181-183] We considered one retrospective cohort study addressing these outcomes to have moderate risk of bias[206] and the second to have high risk.[203]

Sore throat days and diagnosed Group A streptococcal throat infections decreased consistently across studies in children who received tonsillectomy vs. no surgery/watchful waiting with supportive care in the short term (< 12 months). As noted, in three papers in this section, investigators report multiple RCTs and/or nonrandomized trials conducted by the same team (but with unique populations) in single papers. In one such paper, both the RCT and nonrandomized trial[181-183] reported that children in both studies who received tonsillectomy had fewer recorded days of sore throat in a symptom diary than children who had medical management. Using an intention-to-treat analysis for the RCT patients, the study found a decrease of 3.5 (95% CI: 1.8 to 5.2) sore throat episodes over the full 2-year study period for children who underwent tonsillectomy. However, the RCT did not demonstrate a reduction in sore throats per month. The benefit was greatest in those quick to receive tonsillectomy after the onset of infections, with the relative benefit decreasing with longer times to intervention. Children who underwent tonsillectomy within 4 weeks of enrollment had an estimated 8.5 episodes of sore throat avoided, whereas children who waited longer times (up to 52 weeks) had 3.5 episodes of sore throats saved. Limitations of this study family include strong parental preference for surgery when the child had more severe symptoms, thus affecting the generalizability of the patients who were randomized. The study points out that the children who were ultimately randomized fell into the middle of the pack in terms of how much they were impacted by their symptoms. The study also had significant attrition in return of the symptom diaries over time and difficulty obtaining provider records for review.

In another paper reporting two unique studies (one RCT and one nonrandomized trial), benefits of tonsillectomy or adenotonsillectomy were reported for children who experienced at least one sore throat.[258] These studies had surgical and watchful waiting groups, and while the surgical groups had fewer sore throat visits after surgery, the number of sore throat visits in the watchful waiting groups were also low. The first year post-surgery, the tonsillectomy group had 1.74 (95% CI: 1.54 to 2.00) episodes of throat infection while the control group had 2.93 (95%

CI: 2.69 to 3.22) episodes. Although statistically significant, it is unclear whether this difference is clinically meaningful. A previous RCT and nonrandomized trial (2 studies reported in one paper)[11] used more stringent inclusion criteria, requiring more than 7 sore throat episodes in the previous year, 5 or more in the 2 prior years or 3 or more in the past 3 years to show benefit of tonsillectomy for children with severe symptoms and found fewer throat infections in the 2 years after surgery. Due to high crossover and large percentage lost to followup, we considered the study to have high risk of bias.

In another RCT (moderate risk of bias) including children with mild symptoms of throat infection or hypertrophy (< 7 or more throat infections in prior year or 5 or more in prior 2 years or 3 or more in prior 3 years and Brouillette's OSA score of less than 3.5—i.e., in no apnea or possible apnea range), children who received tonsillectomy had fewer throat infections (throat pain+fever) compared with those who had no surgery (0.56/person year vs. 0.77, p= NR).[166-168] Of note, many children originally allocated to no surgery/watchful waiting (n=50 of 149) crossed over to the surgery arm, and the group in which they were analyzed is not clear.

One retrospective cohort found that children who did not undergo tonsillectomy were 3.1 times (95% CI: 2.1 to 4.6, $p < 0.001$) more likely to test positive for Group A streptococcal (GAS) throat infection that their counterparts who underwent surgery.[206]Children who did not have tonsillectomy also experienced GAS infection at a shorter time interval than the children without tonsils. A second retrospective cohort study reported a net reduction in the 3-year mean sore throat visits for children who underwent tonsillectomy compared with those who did not.[203] This reduction decreased over time with 2.46 fewer visits (95% CI: 2.29 to 2.63, $p < 0.001$) in years 1-3 and 1.21 fewer visits (95% CI: 1.04 to 1.38, $p < 0.001$) in years 4-6, or 0.61 sore throat visits per child per year (over the 6 year study period). This study focused on provider visits rather than sore throat episodes that did not generate a provider visit, or visits with multiple concerns, coded under another primary complaint.

In another RCT, school absences decreased in the tonsillectomy group (3.5±4.2 days [n=52]) compared with watchful waiting (6.6±6.2 days [n=58]), $p < 0.01$) in the first year post-procedure, but the difference was not statistically significant in the subsequent years.[11] In a nonrandomized trial differences in school absences were not significant between groups.[11]

One RCT and nonrandomized trial reported quality of life data, which were not markedly different between any of the study arms at the one-year time point.[181-183] Overall, comparative effectiveness assessment of tonsillectomy vs. no surgery to improve number of throat infections, associated health care utilization, days of work/school missed, and quality of life shows a benefit in the first post-surgical year, with diminishing benefit over time.

Table 13. Key infection outcomes in studies comparing tonsillectomy and no surgery in children with recurrent throat infections

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
Koshy 2015[203] Retrospective Cohort G1: Tonsillectomy and ≤3 acute throat infection consultations (450) G2: No tonsillectomy and ≤3 acute throat infection (13442) Moderate RoB	G1: Tonsillectomy and ≤3 acute throat infection consultations (450) G2: No tonsillectomy and ≤3 acute throat infection (13442)	**Utilization** **# throat infection consultations in 3 years prior to study index date, mean±SD** G1: 1.3±1.1 G2: 0.4±0.8 G1 vs. G2: p < 0.001	**Utilization** **# throat infection consultations 4-6 years post-index date, mean** G1: 0.6 G2: 0.93 **Mean difference in consultations, baseline to followup** G1: −0.72 (95% CI: −0.88 to −0.56), p < 0.001 G2: +0.49 (95% CI: 0.46 to 0.52), p < 0.001
Lock 2010[181-183] RCT G1: Tonsillectomy (119) G2: Medical management, (112) Moderate ROB	G1: Tonsillectomy (119) G2: Medical management, (112)	**Throat Infections** **N sore throats, 3 months prior to study entry, mean±SD** G1: 3.09±2.08 G2: 3.34±2.63 **Utilization** **# general practitioner consultations in 2 years prior to study entry, mean±SD** G1+G2: 10.3±6.3 **# consultations for sore throat in 2 years prior to study entry, mean±SD** G1+G2: 6.0±3.7 **Quality of Life** **N respondents** G1: 111 G2: 108 **PedsQL 4.0 Physical Health** G1: 76.26±19.50 G2: 78.75±18.01 **N respondents** G1: 111 G2: 110 **PedsQL 4.0 Psychosocial Health** G1: 70.95±14.18 G2: 72.33±14.86	**Throat Infections** **Sore throats/month, mean±SD** Year 1 G1: 0.50±0.43 (n respondents=119) G2: 0.64±0.49 (n respondents=112) RR=0.70 (95% CI: 0.61 to 0.80), p < 0.001 Year 2 G1: 0.13±0.21(n respondents=83) G2: 0.33±0.43 (n respondents=74) RR=0.54 (95%CI: 042 to 0.70), p < 0.001 **Utilization** **Year 1** **# clinician consultations, mean±SD** G1: 3.99±3.74 G2: 4.38±3.48 RR: 0.91 (95% CI: 0.71 to 1.17) **# sore throat consultations, mean±SD** G1: 1.90±2.84 G2: 2.35±2.35 RR: 0.81 (95% CI: 0.59 to 1.10) **Year 2** **# clinician consultations, mean±SD** G1: 2.84±2.90 G2: 3.40±3.20 RR: 0.83 (95% CI: 0.63 to 1.10) **# sore throat consultations, mean±SD** G1: 0.89±1.44 G2: 1.33±1.56 RR: 0.67 (95% CI: 0.46 to 0.97)

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
			<u>Quality of Life</u> **12 months, N respondents** G1: 71 G2: 52 **PedsQL 4.0 Physical Health** G1: 89.95±16.37 (adjusted effect size: 3.08 [95% CI: 3.11 to 9.27]) G2: 85.34±17.86 **PedsQL 4.0 Psychosocial Health** G1: 83.81±15.31 (adjusted effect size: 2.43 [95% CI: -3.08 to 7.03]) G2: 79.97±17.49 **24 months, N respondents** G1: 63 G2: 53 **PedsQL 4.0 Physical Health** G1: 88.79±17.66 (adjusted effect size: 0.31 [95% CI: -5.74 to 6.37]) G2: 88.05±12.76 **PedsQL 4.0 Psychosocial Health** G1: 84.30±15.02 (adjusted effect size: 0.39 [95% CI: -4.52 to 5.29]) G2: 83.897±12.95
Lock 2010[181-183] Nonrandomized trial G1: Tonsillectomy (349) G2: Medical management, (67) Moderate ROB	G1: Tonsillectomy (349) G2: Medical management, (67)	**<u>Throat Infections</u>** **N sore throat lasting < 2 weeks in 3 months prior to study entry, mean±SD** G1: 3.6±2.5 G2: 2.7±1.6 **<u>Utilization</u>** **# general practitioner consultations in 2 years prior to study entry, mean±SD** G1: 8.6±5.8 G2: 10.3±6.9 **# consultations for sore throat in 2 years prior to study entry, mean±SD** G1: 5.4±3.4 G2: 6.2±4.2 **<u>Quality of Life</u>** **N respondents** G1: 338 G2: 65 **PedsQL 4.0 Physical Health** G1: 76.26±19.50 G2: 78.75±18.01	**<u>Throat Infections</u>** **Sore throats/month, mean±SD** Year 1 G1: 0.71±0.50 G2: 0.59±0.44 Year 2 G1: 0.19±0.36 G2: 0.38±0.34 **<u>Utilization</u>** **Year 1** **# clinician consultations, mean±SD** G1: 3.69±3.33 G2: 3.16±3.14 **# sore throat consultations, mean±SD** G1: 1.86±2.23 G2: 1.63±1.98 **Year 2** **# clinician consultations, mean±SD** G1: 2.71±3.51 G2: 3.12±3.10 **# sore throat consultations,**

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
		N respondents G1: 334 G2: 66 **PedsQL 4.0 Psychosocial Health** G1: 70.95±14.18 G2: 72.33±14.86	**mean±SD** G1: 0.78±1.31 G2: 1.45±2.07 **<u>Quality of Life</u>** **12 months** **N respondents** G1: 117 G2: 27 **PedsQL 4.0 Physical Health** G1: 87.15±15.00 G2: 84.66±16.00 **N respondents** G1: 118 G2: 27 **PedsQL 4.0 Psychosocial Health** G1: 82.27±15.83 G2: 82.78±16.12 **24 months** **N respondents** G1: 96 G2: 25 **PedsQL 4.0 Physical Health** G1: 91.35±14.48 G2: 91.88±9.59 **N respondents** G1: 95 G2: 25 **PedsQL 4.0 Psychosocial Health** G1: 85.85±13.78 G2: 87.46±10.38
Orvidas 2006[206] Retrospective Cohort Moderate ROB	G1: Tonsillectomy (145) G2: No surgery (145)	**<u>Throat Infections</u>** **N with infection within one year prior to tonsillectomy/study entry, (%)** G1: 141 (97.2) G2: 130 (89.7)	**<u>Throat Infections</u>** **Cumulative Incidence of Developing Group A Beta-hemolytic Streptococcal Throat Infection, % (95%CI)** At 6 months G1: 13.2 (7.5 to 18.6) Number still at risk: 124 G2: 39.3 (30.8 to 46.8) Number still at risk: 87 At 1 year G1: 23.1 (15.9 to 29.7) Number still at risk: 107 G2: 58.5 (49.6 to 65.9) Number still at risk: 57 At 2 years G1: 38.5 (29.8 to 46) Number still at risk: 83 G2: 74.8 (66.4 to 81.1) Number still at risk: 34

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
			At 3 years G1: 46.1 (37.1 to 53.9) Number still at risk: 65 G2: 82.2 (74.5 to 87.6) Number still at risk: 21 At 4 years G1: 51.9 (42.4 to 59.8) Number still at risk: 39 G2: 84.6 (76.7 to 89.8) Number still at risk: 12
Van Staaij 2004[166-168] RCT Moderate RoB	G1: Tonsillectomy (133) G2: Watchful waiting 124)	**<u>Throat Infections</u>** **Throat infections in year prior to study, median (range)** G1: 3 (0-6) G2: 3 (0-6)	**<u>Throat Infections</u>** **Episodes of throat infection/person year, n** G1: 0.56 G2: 0.83 Difference: -0.21 (95% CI: -0.36 to -0.06) **Incidence rate** G1+G2: 0.73 (95% CI: 0.58 to 0.92)
Paradise 2002[9] RCT A Moderate ROB	G1: Tonsillectomy (58 randomized, 52 received intervention) G2: Adenotonsillectomy (59 randomized, 50 received intervention) G3: No surgery (60 randomized, 60 received intervention)	**<u>Throat Infections</u>** G1+G2: NR	**<u>Throat Infections</u>** **Episodes of Any Throat Infection, Mean (95% CI)** Years 1-3 G1: 1.55 (95% CI: 1.33 to 1.82) G2: 1.63 (95% CI: 1.37 to 1.93) G3: 2.77 (95% CI: 2.52 to 3.13) G1 vs. G3: p < 0.001 G2 vs. G3: p < 0.001 **Episodes of Group A Beta-hemolytic Streptococcal Throat Infection, Mean (95% CI)** Years 1-3 G1: 0.29 (95% CI: 0.20 to 0.41) G2: 0.20 (95% CI: 0.12 to 0.32) G3: 0.82 (95% CI: 0.67 to 1.01) G1 vs. G3: p < 0.001 G2 vs. G3: p < 0.001 **Episodes of Moderate or Severe Throat Infection, Mean (95% CI)** Years 1-3 G1: 0.09 (95% CI: 0.04 to 0.17) G2: 0.08 (95% CI: 0.03 to 0.17) G3: 0.33 (95% CI: 0.24 to 0.45) G1 vs. G3: p=0.002 G2 vs. G3: p=0.003

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
Paradise 2002[9] RCT B Moderate ROB	G1: Adenotonsillectomy (73 randomized, 63 received intervention) G2: No surgery (78 randomized, 78 received intervention)	**Throat Infections** G1+G2: NR	**Throat Infections** **Episodes of Any Throat Infection, Mean (95% CI)** Years 1-3 G1: 1.74 (95% CI: 1.54 to 2.00) G2: 2.93 (95% CI: 2.69 to 3.22) G1 vs. G2: p < 0.001 **Episodes of Group A Beta-hemolytic Streptococcal Throat Infection, Mean (95% CI)** Years 1-3 G1: 0.29 (95% CI: 0.21 to 0.40) G2: 0.77 (95% CI: 0.65 to 0.92) G1 vs. G2: p < 0.001 **Episodes of Moderate or Severe Throat Infection, Mean (95% CI)** Years 1-3 G1: 0.07 (95% CI: 0.03 to 0.13) G2: 0.28 (95% CI: 0.21 to 0.37) G1 vs. G2: p=0.003
Paradise 1984[11] RCT High ROB	G1: Tonsillectomy (43) G2: Nonsurgical treatment (48)	**Throat Infections** **History of Episodes of Throat Infection Prior to Study Entry, n (%)** ≥7 in 1 year G1: 20 (47) G2: 11 (23) ≥5/year for 2 years G1: 5 (12) G2: 5 (10) ≥3/year for 3 years G1: 18 (42) G2: 32 (67)	**Throat Infections** **Mean Episodes Any Throat Infection/Participant (Total Episodes)** Year 1 G1: 1.24 (47) G2: 3.09 (108) G1 vs. G2: p=0.001 Year 2 G1: 1.61 (50) G2: 2.66 (77) G1 vs. G2: p=0.001 Year 3 G1: 1.77 (39) G2: 2.20 (44) G1 vs. G2=0.001 **Mean Episodes Group A Beta-hemolytic Streptococcal Throat Infection/Participant (Total Episodes)** Year 1 G1: 0.42 (16) G2: 1.00 (35) G1 vs. G2: p=0.007 Year 2 G1: 0.19 (6) G2: 0.93 (27) G1 vs. G2: p=0.001 Year 3 G1: 0.36 (8)

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
			G2: 0.75 (15) G1 vs. G2: p=NS **Mean Episodes Moderate to Severe Throat Infection/Participant (Total Episodes)** Year 1 G1: 0.08 (3) G2: 1.17 (41) G1 vs. G2: p=0.001 Year 2 G1: 0.16 (5) G2: 1.03 (30) G1 vs. G2: 0.002 Year 3 G1: 0.27 (6) G2: 0.45 (9) G1 vs. G2: p=NS
Paradise 1984[11] Nonrandomized trial High ROB	G1: Tonsillectomy (52) G2: Nonsurgical treatment (44)	**Throat Infections** **History of Episodes of Throat Infection Prior to Study Entry, n (%)** ≥7 in 1 year G1: 18 (35) G2: 13 (30) ≥5/year for 2 years G1: 11(21) G2: 6 (14) ≥3/year for 3 years G1: 23 (44) G2: 25 (57)	**Throat Infections** **Mean Episodes Any Throat Infection/Participant (Total Episodes)** Year 1 G1: 1.77 (78) G2: 3.09 (105) G1 vs. G2: p=0.04 Year 2 G1: 1.18 (40) G2: 2.50 (70) G1 vs. G2: p=0.001 Year 3 G1: 1.47 (22) G2: 3.15 (41) G1 vs. G2=0.04 **Mean Episodes Group A Beta-hemolytic Streptococcal Throat Infection/Participant (Total Episodes)** Year 1 G1: 0.32 (14) G2: 0.76 (26) G1 vs. G2: p=0.02 Year 2 G1: 0.09 (3) G2: 0.86 (24) G1 vs. G2: p=0.001 Year 3 G1: 0.47(7) G2: 1.15 (17) G1 vs. G2: p=NS

Author, Year Study Type RoB	Comparison Groups (n)	Outcome Measure Baseline (mean)	Outcome Measure Followup (mean)
			Mean Episodes Moderate to Severe Throat Infection/Participant (Total Episodes) Year 1 G1: 0.30 (13) G2: 0.68 (23) G1 vs. G2: p=NS Year 2 G1: 0.12 (4) G2: 0.39 (11) G1 vs. G2: p=0.02 Year 3 G1: 0.33 (5) G2: 0.85 (11) G1 vs. G2: p=NS

CI = Confidence Interval; G = Group; n = Number; NR = Not Reported; NS = Not Significant; PedsQL = Pediatric Quality of Life Questionnaire; RoB = Risk of Bias

Fewer days of missed school or work were associated with tonsillectomy in the short term, with differences diminishing over time (Table 14).

Table 14. Missed school or work outcomes reported in studies comparing tonsillectomy and no surgery in children with recurrent throat infections

Author, Year Study Type RoB	Comparison Groups (n)	Sore Throat-Associated School Absences, Mean ±SD Days/Year (Number Days/Year)
Paradise 2002[9] RCT A G1: Tonsillectomy (58 randomized, 52 received intervention) G2: Adenotonsillectomy (59 randomized, 50 received intervention) G3: No surgery (60 randomized, 60 received intervention) Moderate ROB	G1: Tonsillectomy (58 randomized, 52 received intervention) G2: Adenotonsillectomy (59 randomized, 50 received intervention) G3: No surgery (60 randomized, 60 received intervention)	Year 1 G1: 3.3±4.0 (42) G2: 3.9±3.7 (44) G3: 5.3±4.7 (50) G1 vs. G3: p < 0.05 Year 2 G1: 3.2±3.9 (39) G2: 2.4±3.2 (38) G3: 5.0±5.2 (44) G2 vs. G3: p < 0.05 Year 3 G1: 2.5±3.2 (37) G2: 2.9±2.9 (29) G3: 3.7±3.2 (42) G2 vs. G3: p=NS
Paradise 2002[9] RCT B Moderate ROB	G1: Tonsillectomy (73 randomized, 63 received intervention) G2: No surgery (78 randomized, 78 received intervention)	Year 1 G1: 3.5±4.2 (52) G2: 6.6±6.2 (58) G1 vs. G2: p < 0.01 Year 2 G1: 3.2±4.1 (47) G2: 5.4±6.7 (56) G1 vs. G2: p=NS

		Year 3 G1: 2.6±3.4 (45) G2: 4.2±5.2 (55) G1 vs. G2: p=NS
Paradise 1984[11] RCT G1: Tonsillectomy (43) G2: Nonsurgical treatment (48) High ROB	G1: Tonsillectomy (43) G2: Nonsurgical treatment (48)	Year 1 G1: 3.5±4.2 (29) G2: 6.7±6.9 (30) G1 vs. G2: p < 0.05 Year 2 G1: 4.5±4.5 (28) G2: 5.9±4.2 (26) G1 vs. G2: p=NS Year 3 G1: 5.1±5.7 (21) G2: 5.9±6.2 (21) G1 vs. G2: p=NS
Paradise 1984[11] Nonrandomized trial High ROB	G1: Tonsillectomy (52) G2: Nonsurgical treatment (44)	Year 1 G1: 6.3±6.7 (41) G2: 7.4±8.6 (31) Year 2 G1: 4.4±5.6 (25) G2: 4.3±3.9 (25) Year 3 G1: 4.0±5.9 (10) G2: 7.2±7.8 (13)

G = Group; n = Number; NS = Not Significant; RCT = Randomized Controlled Trial; RoB = Risk of Bias; SD = Standard Deviation

Key Question 3. Effectiveness of Partial vs. Total Tonsillectomy

Key Points

- Strength of the evidence is low for no difference in effects on OSDB persistence; low for faster return to normal diet after partial tonsillectomy; and insufficient to assess effects on throat infection in studies comparing partial vs. total cold dissection tonsillectomy. Strength of the evidence is insufficient to assess effects on return to normal diet or activity in studies comparing either partial or total coblation tonsillectomy or partial vs. total electrocautery tonsillectomy.
- Strength of the evidence is low for more favorable return to normal diet and activity in children undergoing partial vs. total tonsillectomy; low for no difference in effects on long-term (>12 months) persistence of OSDB symptoms, quality of life, behavioral outcomes, or throat infections in studies comparing mixed techniques.
- Few studies (n=6) compared the same surgical technique for partial or total tonsillectomy. Among those four comparing partial cold dissection with total cold dissection, outcomes were generally not different except for a faster return to normal diet after partial tonsillectomy. Among those comparing partial or total coblation or partial or total electrocautery, return to normal and activity were more favorable in children undergoing partial tonsillectomy compared with total.

- In studies we considered to evaluate partial vs. total tonsillectomy in which surgical techniques also differed (n=12), differences in clinical outcomes between partial and total tonsillectomy were generally not significant.
- In six studies addressing return to normal diet or activity and comparing partial and total tonsillectomy regardless of technique, children in the partial tonsillectomy arms had more favorable outcomes compared with those receiving total tonsillectomy; however, these effects may be due to confounding by indication as indication varied across studies.
- Across all studies, 14 out of an estimated 220 children (6.4%) had tonsillar regrowth after partial tonsillectomy, 12 of whom had total completion tonsillectomy as a revision surgery.

Overview of the Literature

We identified 20 unique studies (18 RCTs[55, 73, 86-88, 92, 97, 99, 100, 103, 109, 112, 131, 141, 153, 160, 184-189, 194] and 2 nonrandomized trials[189, 194]) addressing partial tonsillectomy compared with total tonsillectomy (Table 15). Most studies were conducted in Europe[55, 86, 88, 103, 131, 187-189, 194] or North America.[87, 92, 97, 99, 100, 109, 112, 153] Two studies were conducted in Asia,[73, 141] and one in Africa.[160] Participants (n=2690) ranged in age from 1 to 8 years. In addition to comparing partial with total tonsil removal, most studies (n=13) also compared surgical techniques including microdebrider, laser, coblation, and electrocautery partial tonsillectomy and cold dissection, coblation, and electrocautery total tonsillectomy. In studies comparing both partiality/totality and different surgical techniques (e.g., partial coblation vs. total electrocautery), it is not possible to determine whether effects are due to the technique or due to the amount of tissue removed. Thus, except for in those studies that compared partial or total removal of the tonsils using the same technique (e.g., partial cold dissection vs. total cold dissection), we considered the comparison of interest broadly as partial vs. total tonsil removal. We present results by partial vs. total cold dissection, partial vs. total coblation or electrocautery; and partial vs. total regardless of technique below.

Across studies, "partial" tonsillectomy was variously or not explicitly defined. Five studies explicitly noted leaving anywhere from 10 to 70 percent of the tonsil intact,[55, 86, 88, 112, 131] while others noted leaving a thin rim of tissue or removing the bulk of the tonsil,[73, 87, 92, 109, 194] and yet others reported removing the obstructive or protruding portion of the tonsil only.[184-189] Six studies did not describe the portion of tissue removed.[97, 99, 100, 141, 153, 160]

We considered five RCTs to have low risk of bias.[55, 92, 99, 100, 153, 160] Eleven RCTs[73, 86-88, 97, 109, 112, 141, 184-188] and two nonrandomized trials[189, 194] had moderate risk of bias, and two RCTs[259, 260] had high risk of bias. We do not discuss high risk of bias studies in the detailed analyses below.

Table 15. Overview of studies comparing partial vs. total tonsillectomy

Characteristic	RCTs	Nonrandomized Trials	Total Literature
Comparisons			
Total cold dissection vs. partial cold dissection	3	1	4
Total coblation vs. partial coblation	1	0	1
Total electrocautery vs. partial electrocautery	1	0	1

Partial vs. total	13	1	14
Surgical Indication			
OSDB	15	2	17
OSDB+Throat Infection	2	0	2
Not specified	1	0	1
Effectiveness Outcomes Frequently Reported			
Return to normal diet or activity	10	0	10
Number of throat infections	5	0	5
Tonsillar regrowth	4	1	5
Risk of Bias			
Low	5	0	5
Moderate	11	2	13
High	2	0	2
Total N participants	**1474**	**1216**	**2690**

n = number; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Detailed Analysis

Partial Cold Dissection vs. Total Cold Dissection Tonsillectomy

Three RCTs and one nonrandomized trial compared total and partial cold dissection and included 348 children in the partial tonsillectomy arms and 378 in the total tonsillectomy arms.[55, 86, 88, 194] Few of these studies reported the same outcomes (Table 16).

OSDB Persistence

In the one RCT and one nonrandomized trial (low risk of bias) reporting on the persistence of OSDB, children in both arms had recurrence of snoring[55, 194] Differences were not statistically significant in one study,[55] and while the second study did not report significance, 2/6 children required complete tonsillectomy to address continued snoring up to 18 months after the index surgery.[194] Only 112 children of the 1023 originally studied, however, provided data for longer-term followup.

Tonsillar Regrowth and Reoperation

Two RCTs (low[55] and moderate[86] risk of bias) and one nonrandomized trial[194] (moderate risk of bias) addressed regrowth and/or revision surgery. In one RCT including 40 children with OSDB undergoing partial tonsillectomy and 41 undergoing total, no children had tonsillar regrowth (0 of 68 followed up) in the 2-year followup period.[86] In a second study, 6 out of 13 children undergoing partial tonsillectomy and followed for 6 years had regrowth, in two cases requiring total tonsillectomy.[55] In the final study 2 of 57 children followed required total tonsillectomy.[194]

Growth

No studies provided baseline comparative data that could be used to assess the comparative effectiveness of surgery on growth outcomes.

Return to Normal Diet or Activity

Children in the partial tonsillectomy arm had significantly faster return to normal diet in the two RCTs (low and moderate risk of bias) addressing this outcome (p values< 0.001).[55, 88]

Throat infection

In one low risk of bias RCT with 6-year followup, no children (0/91) in either group had throat infections, although the study reports that five children in the partial tonsillectomy arm had at least one episode of tonsillitis/year in the followup period.[55] The study did not define throat infection or tonsillitis.

Table 16. Comparative effectiveness outcomes in studies addressing partial vs. total cold dissection tonsillectomy

Author, Year Study Design Risk of Bias	Comparison Groups (n)	OSDB persistence	Tonsillar Regrowth	Return to Normal Diet or Activity	Throat Infections
Chaidas 2013[55] RCT Low RoB	G1: Partial cold tonsillectomy (50) G2: Total cold tonsillectomy (51)	Snoring (6-years post-tonsillectomy) G1: 13/43 (30.2) G2: 12/48 (25) G1 vs. G2: p=NS Episodes of apnea (6-years post-tonsillectomy) G1: 2/43 (4.7) G2: 0 (0) G1 vs. G2: p=NS	Tonsillar regrowth, 6 years post-surgery, n (%) G1: 6/13 (46.2) G2: NA Tonsillar regrowth requiring revision surgery, n (%) G1: 2/13 (5) G2: 0	Time to return to normal diet, mean days ± SD G1: 3.8 ± 0.2 G2: 7.1 ± 0.3 G1 vs.G2: P < 0.001	At least 1 episode of tonsillitis/year, 1-6 years post-tonsillectomy, n (%) G1: 5 (11.6) G2: 0 G1 vs. G2: p= NR Number throat infections/year, 1-6 years post-tonsillectomy, median (IQR) G1: 0 (0-1) G2: 0 (0-1) G1 vs. G2: p=NS
Vlastos 2008[194] Nonrandomized trial Moderate RoB	G1: Partial cold dissection tonsillectomy (243) G2: Total cold dissection tonsillectomy (780)	Recurrence of snoring ~18 months post-tonsillectomy, n (%) G1: 6/57 (11) G2: 3/55 (5) G1 vs. G2: p=NR	Tonsillar regrowth/obstruction requiring total tonsillectomy, n G1: 2/57 G2: NA	NR	NR
Korkmaz 2008[86] RCT Moderate RoB	G1: Partial cold tonsillectomy (40) G2: Total cold tonsillectomy (41)	NR	Tonsillar regrowth within 2-years post-tonsillectomy, n G1+G2: 0/68	NR	NR
Skoulakis 2007[88] RCT Moderate RoB	G1: Partial cold tonsillectomy (15) G2: Total cold tonsillectomy (15)	NR	NR	Time to return to normal diet G1: 4 days earlier than G2 G1 < G2: p < 0.001	NR

G = Group; N = Number; NA = Not Applicable; NR = Not Reported; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Partial Coblation or Electrocautery vs. Total Coblation or Electrocautery

Two small RCTs with low[92] and moderate[87] risk of bias addressed outcomes following partial vs. total coblation or electrocautery and reported only on return to usual diet or activity (Table 17). In the coblation study, children in the partial tonsillectomy arm consumed a significantly greater percentage of normal diet and were engaged in a greater portion of normal activity than were children in the total tonsillectomy arm at all time points assessed.[87] Similarly, in the one study comparing partial vs. total electrocautery tonsillectomy, children in the partial tonsillectomy arm had a significantly faster return to normal activity than did children in the total tonsillectomy arm.[92]

Table 17. Return to usual diet or activity in studies addressing partial vs. total tonsillectomy with coblation or electrocautery

Author, Year Study Type RoB	Comparison Groups (n)	Time to Return to Normal Diet or Activity, N (%)
Chang 2008[87] RCT Moderate RoB	G1: Partial coblation tonsillectomy (34) G2: Total coblation tonsillectomy (35)	**Mean % of normal diet resumed (POD1-2)** G1: 56 G2: 42 G1 vs.G2: p = 0.05 **Mean % of normal diet resumed (POD5-6)** G1: 73 G2: 48 G1 vs.G2: p < 0.05 **Mean % of normal activity resumed (POD1-2)** G1: 65 G2: 49 G1 vs.G2: p = 0.031 **Mean % of normal activity resumed (POD5-6)** G1: 84 G2: 64 G1 vs.G2: p = 0.002
Park 2007[92] RCT Low RoB	G1: Partial electrocautery tonsillectomy (19) G2: Total electrocautery tonsillectomy (21)	**Time to return to normal activity** **G1 vs.G2: p = NS**

G = Group; N = Number; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; POD = Postoperative Day; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Partial Tonsillectomy vs. Total Tonsillectomy with mixed surgical approaches

Among the 12 studies of low or moderate risk of bias addressing partial vs. total tonsillectomy without using the same surgical technique, nine (reported in multiple publications) addressed effectiveness outcomes[97, 99, 100, 109, 112, 141, 184-189] and three reported only harms (addressed in Harms section).[73, 153, 160] As with the studies outlined above, few studies addressed the same outcomes and because these studies differ in both partiality and surgical technique, it is difficult to isolate the effect of partial tonsillectomy.

OSDB Persistence

Three RCTs (in multiple publications) addressed outcomes related to the persistence of OSDB (Table 18).[112, 184-188] In two studies with low[92] and moderate[187, 188] risk of bias, obstructive symptoms including snoring worsened in the short term in the partial tonsillectomy arm compared with total tonsillectomy, but differences between groups were not significant at longer-term followup (12-24 months post-tonsillectomy. In the third RCT, no children in either group had snoring or apnea at 1 and 3 years postoperatively.[184-186]

Table 18. OSDB persistence reported in studies comparing partial and total tonsillectomy

Study, Year Study Design Risk of Bias	Comparison Groups (n)	OSDB Persistence
Chan 2004[112] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (27) G2: Total tonsillectomy-electrocautery (28)	**Worsening of obstructive symptoms (3-months post-tonsillectomy), n (%)** G1: 10/21 (48) G2: 6/19 (25) p=NR Improvement in obstructive symptoms (12 months post-tonsillectomy) G1 vs. G2: p=NS
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (35) G2: Total tonsillectomy-cold dissection (32)	**Persistence of snoring** 6-months post-tonsillectomy Greater number of children in G1 vs. G2 had snoring, p < 0.05 24-months post-tonsillectomy G1 vs. G2; p=NS
Hultcrantz 2004[184-186] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (49) G2: Total tonsillectomy-cold dissection (43)	**Persistence of snoring** 12-months and 3-years post-tonsillectomy No difference in frequency or loudness of snoring between groups Presence of apnea 1-3 years post-tonsillectomy G1: 0 G2: 0

G = Group; N = Number; NR = Not Reported; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Tonsillar Regrowth

Two RCTs and one nonrandomized trial (all with moderate risk of bias) reported low rates of tonsillar regrowth after partial tonsillectomy (Table 19).[184-189] Out of an estimated 150 children providing followup data, six (4%) reported regrowth and had total tonsillectomy.

Table 19. Tonsillar regrowth or reoperation after partial tonsillectomy

Study, Year Study Design Risk of Bias	Comparison Groups (n)	Tonsillar Regrowth
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (35) G2: Total tonsillectomy-cold dissection (32)	**Total tonsillectomy for OSDB-symptom persistence, n (%)** G1: 2/35 (5.7) G2: NA
Hultcrantz 2004[184-186] RCT	G1: Partial tonsillectomy-coblation (49) G2: Total tonsillectomy- Cold	**Total tonsillectomy for OSDB-symptom persistence, n** G1: 1 (denominator not clear, 91 children in both

Moderate RoB	dissection (43)	groups assessed at 1 year) G2: NA
Moriniere 2013[189] Nonrandomized trial Moderate RoB	G1: Partial tonsillectomy-coblation (88) G2: Total tonsillectomy-electrocautery (105)	**Tonsillar regrowth requiring complete tonsillectomy within 1-year, n (%)** G1: 3/66 (4.5) G2: NA

G = Group; N = Number; NA = Not Applicable; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Return to Normal Diet or Activity

Six RCTs (four with moderate and two with low risk of bias) addressed time to return to normal diet or activity (Table 20).[97, 99, 100, 109, 112, 187, 188] Studies were typically small (< 100 children) with short term followup and variable methods for assessing these outcomes (e.g., mean days, mean percentage, number of children). In all six studies addressing return to normal diet, children in the partial tonsillectomy arms had favorable outcomes compared with those receiving total tonsillectomy. Two studies reported that children undergoing partial surgeries either consumed a significantly greater proportion of their normal diet[109] or returned to normal diet in fewer days[99] than did children in total tonsillectomy arms. Four RCTs reported faster return in the partial tonsillectomy groups or greater numbers of children consuming a normal diet after partial compared with total tonsillectomy, but differences were not statistically significant[100, 187, 188] or significance was not assessed.[97, 112]

Five RCTs (2 low and 3 moderate risk of bias) addressed return to normal activity.[99, 100, 109, 112, 187, 188] As with diet, in all studies children undergoing partial tonsillectomy had a faster return to normal activity or engaged in a greater percentage of normal activity than did children who had total tonsillectomy. Differences were statistically significant in two RCTs[100, 109]

Table 20. Return to normal diet or activity in studies comparing partial and total tonsillectomy

Author, Year Study Type RoB	Comparison Groups (n)	Time to Return to Normal Diet or Activity, N (%)
Chang 2005 [109] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (52) G2: Total tonsillectomy- electrocautery (49)	**Mean % of normal diet resumed (POD1-2)** G1: 49 G2: 30 G1 vs.G2: p < 0.005 **Mean % of normal diet resumed (POD5-6)** G1: 74 G2: 42 G1 vs.G2: p < 0.005 **Mean % of normal activity resumed (POD1-2)** G1: 53 G2: 42 G1 vs.G2: p = NS **Mean % of normal activity resumed (POD5-6)** G1: 82 G2: 56 G1 vs.G2: p < 0.005
Chan 2004 [112] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (25) G2: Total tonsillectomy- electrosurgery (25)	**Time to return to normal diet, median days** G1: 4.4 G2: 7.5 G1 vs.G2: p = NR **Time to return to normal activity, median**

		days G1: 4.1 G2: 8 G1 vs.G2: p = NR
Coticchia 2006[97] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (13) G2: Total tonsillectomy-cold (10)	**N children resuming normal diet by POD7, (%)** G1: 11 (85) G2: 0 (0) G1 vs.G2: p = NR
Sobol 2006[99] RCT Low RoB	G1: Partial tonsillectomy-microdebrider (36) G2: Total tonsillectomy-electrocautery (38)	**Time to return to normal diet, mean days ± SD** G1: 2.7 ± 2.3 G2: 4.4 ± 3.4 G1 vs.G2: p = 0.04 **Time to return to normal activity, mean days ± SD** G1: 2.4 ± 1.8 G2: 3.8 ± 3 G1 vs.G2: p = NS
Derkay 2006[100] RCT Low RoB	G1: Partial tonsillectomy-microdebrider (150) G2: Total tonsillectomy-electrocautery (150)	**Time to return to normal diet, median (Q1 – Q3)** G1: 3 (1.5-6) G2: 3.5 (1.5-6.5) G1 vs.G2: p = NS **Time to return to normal activity, median (Q1 – Q3)** G1: 2.5 (1-5) G2: 4 (2.5-6.5) G1 vs.G2: p < 0.01
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (35) G2: Total tonsillectomy-cold dissection (32)	**Time to return to normal diet** G1: 4 days earlier than G2 G1 vs. G2: p=NS **Time to return to normal activity** G1: 3 days earlier than G2 G1 vs. G2: p=NS

G = Group; N = Number; NR = Not Reported; NS = Not Significant; POD = Postoperative Day; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Throat Infections

Four RCTs (multiple publications, all moderate risk of bias) addressed recurrent throat infections (Table 21).[112, 141, 184-188] One study included children with OSDB (hypertrophy causing obstruction) as the primary indication for surgery,[261] while the others included children with both OSDB and recurrent throat infections. Two studies explicitly reported on baseline or previous throat infections (number of episodes/year),[112, 184-186] and one explicitly excluded children with >3 streptococcal throat infections in the 2 years prior to surgery.[141] One study reported that 21 percent of all children had had ≤ one episodes of tonsillitis before the 3 months prior to surgery.[187, 188] In three of the four studies, children in the partial tonsillectomy arm had more throat infections than did those in the total tonsillectomy arms, though differences were not statistically significant in three studies.[112, 184-188] In two studies, children experienced fewer infections compared with baseline rates,[184-188] but other studies did not comment on changes from baseline.

Table 21. Throat infections following partial or total tonsillectomy

Study, Year Study Design Risk of Bias	Comparison Groups (n)	Throat Infections
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy- coblation (35) G2: Total tonsillectomy- cold dissection (32)	**Sore throats requiring antibiotics, 6-months post-tonsillectomy, n** G1: 4 G2: 2 G1 vs. G2: p=NS Sore throats requiring antibiotics, 24-months post-tonsillectomy, n G1: 8 G2: 1 G1 vs. G2: p= NR
Hultcrantz 2004[184-186] RCT Moderate RoB	G1: Partial tonsillectomy- coblation (49) G2: Total tonsillectomy- Cold dissection (43)	**Sore throats requiring antibiotics, 12-months post-tonsillectomy, n** G1: 6 G2: 4 G1 vs. G2: p=NS **Sore throats requiring antibiotics, 1-3 years post-tonsillectomy, n** G1: 6 G2: 5 G1 vs. G2: p=NS
Beriat 2013[141] RCT Moderate RoB	G1: Partial tonsillectomy- microdebrider (37) G2: Total tonsillectomy- cold dissection (45)	**Recurrent throat infection (within 12-months post-tonsillectomy), n** G1: 2 G2: 0 G1 vs. G2: p= NR
Chan 2004[112] RCT Moderate RoB	G1: Partial tonsillectomy- coblation (27) G2: Total tonsillectomy- electrocautery (28)	**Incidence of sore throat or antibiotic use (3 and 12 months post-tonsillectomy)** G1 vs. G2: p=NS

G = Group; N = Number; NR = Not Reported; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Quality of Life

Three RCTs (1 low and 2 moderate risk of bias) assessed quality of life using different scales and at different time points (Table 22).[100, 184-188] In one study with assessment at 1-month post-surgery, differences in physical suffering, sleep disturbances, speech issues, or caregiver concerns did not differ between groups, but decreases in emotional distress and activity limitations were greater the partial tonsillectomy arm than in the total tonsillectomy arm.[100] In two additional studies (one using the OSA-18, which uses a 7-point scale to assess frequency of symptoms from 1 [none of the time] to 7 [all of the time] and also assesses disease-specific quality of life) and one using the Glasgow Children's Benefit Inventory [GCBI]), differences in quality of life were not significant between groups, and both groups improved from baseline. In one study more than 30 percent of children in both arms had large improvements in disease-specific quality of life at 6 months and 2 years post-surgery, but group differences were not significant.[187, 188]

Table 22. Quality of life following partial or total tonsillectomy

Study, Year Study Design Risk of Bias	Comparison Groups (n)	Baseline Outcome Measure, Mean±SD	Followup Outcome Measure, Mean±SD
Derkay 2006[100] RCT Low RoB	G1: Partial tonsillectomy-microdebrider (150) G2: Total tonsillectomy-electrocautery (150)	NR	**Baseline to postoperative changes in physical suffering, sleep disturbance, speech or swallowing problems, and caregiver concerns, 1 month post-tonsillectomy** G1 vs. G2: p=NS Decrease in emotional distress G1>G2: p < 0.01 Decrease in activity limitation G1>G2: p < 0.01
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (35) G2: Total tonsillectomy- cold dissection (32)	**OSA-18 (Total), Mean±SD** G1: 3.5±1.0 G2: 3.4±1.0	**OSA-18 (Total)** Change score 6-months post-tonsillectomy G1: 1.8±1.2 G2: 1.8±1.0 G1 vs. G2: p=NS Change score 24-months post-tonsillectomy G1: 1.8±1.2 G2: 1.9±1.4 G1 vs. G2: p=NS Disease-specific quality of life data in figures only
Hultcrantz 2004[184-186] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (49) G2: Total tonsillectomy- cold dissection (43)	**Glasgow Children's Benefit Inventory** G1+G2: NR	**Glasgow Children's Benefit Inventory, %** 33 months post-tonsillectomy Overall QoL-Much better G1: 61 G2: 79 Overall QoL-A little better G1: 35 G2: 18 Overall QoL-No change G1: 5 G2: 3 G1 vs. G2: all p=NS

G = Group; IQR = Interquartile Range; N = Number; NR = Not Reported; NS = Not Significant; OSA-18 = Obstructive Sleep Apnea - 18; OSDB = Obstructive Sleep Disordered Breathing; QoL = Quality of Life; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Behavioral Outcomes

Two RCTs with moderate risk of bias reported changes in behavior using the Child Behavior Checklist (CBC) (Table 23).[184-188] Both groups improved from baseline overall and in each domain assessed (internalization, externalization), with no significant differences between groups in the short or longer (≥12 months) term. One study also assessed behavior changes with the GCBI and reported no significant differences between groups.[184-186]

Table 23. Behavioral outcomes following partial or total tonsillectomy

Study, Year Study Design Risk of Bias	Comparison Groups (n)	Baseline Outcome Measure, Mean±SD	Followup Outcome Measure, Mean±SD
Ericsson 2009[187, 188] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (35) G2: Total tonsillectomy-cold dissection (32)	**Child Behavior Checklist, Total Score** G1: 25.6±19.1 G2: 20.9±12.4 G1 vs. G2: p=NS	**Child Behavior Checklist, Total Score** 6-months post-tonsillectomy G1: 19.5 ±18.4 G2: 13.5 ±9.8 G1 vs. G2: p=NS 24-months post-tonsillectomy G1: 13.9±12.9 G2: 13.6±21.7 G1 vs. G2: p=NS
Hultcrantz 2004[184-186] RCT Moderate RoB	G1: Partial tonsillectomy-coblation (49) G2: Total tonsillectomy-cold dissection (43)	**Child Behavior Checklist, Total Score, Mean±SD** G1: 21.3±17.4 G2: 17.3±12.8 G1 vs. G2: p < 0.001	**Child Behavior Checklist, Total Score** 12-months post-tonsillectomy No differences in degree of improvement between groups Glasgow Children's Benefit Inventory, % 33 months post-tonsillectomy Behavior-Much better G1: 19 G2: 10 Behavior-A little better G1: 19 G2: 15 Behavior-No change G1: 62 G2: 74 G1 vs. G2: all p=NS

G = Group; N = Number; NS = Not Significant; OSDB = Obstructive Sleep Disordered Breathing; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Other Outcomes

Two RCTs with moderate risk of bias also addressed enuresis.[184-188] One study reported a second partial tonsillectomy in a child with pre-existing enuresis and encopresis temporarily improved by the index partial tonsillectomy; encopresis did not improve after the second surgery.[187, 188] Another reported that 7 children undergoing total tonsillectomy and 3 undergoing partial had baseline enuresis, which improved in nine children (treatment group not specified) postoperatively.[184-186]

Detailed Analysis

Key Question 4. Effectiveness of Surgical Techniques

Key Points

- Strength of the evidence is low for a moderately faster return to diet associated with coblation tonsillectomy compared with cold dissection and low for a faster return to normal diet following electrocautery compared with cold dissection tonsillectomy. Strength of evidence is insufficient to assess outcomes associated with other techniques.
- Few studies reported effectiveness outcomes.
- Frequently used "hot" techniques such as coblation and electrocautery were generally associated with faster recovery (as measured by return to normal diet or activity) than was cold dissection.
- Few studies, typically addressing different measures and using different comparison techniques, addressed newer techniques such as thermal welding, lase, or harmonic scalpel, thus limiting our ability to draw conclusions about these approaches.

Overview of the Literature

We identified 58 unique studies (reported in 61 publications) comparing surgical techniques for tonsillectomy (Table 24).[45, 50, 58, 60, 63, 65-72, 76, 77, 79, 81-85, 89, 91, 93, 95, 98, 101, 102, 104-106, 110, 113, 118, 122, 125-127, 129, 132, 133, 136, 143, 145-147, 154-156, 162, 165, 169-172, 191-193, 196, 201] Most (n=53) studies were RCTs;[45, 50, 58, 60, 63, 65-72, 76, 77, 79, 81-85, 89, 91, 93, 95, 98, 101, 102, 104-106, 110, 113, 118, 122, 125-127, 129, 132, 133, 136, 143, 145-147, 154-156, 162, 165, 169-172] four were nonrandomized trials,[191-193, 196] and one was a prospective cohort study.[201] Twenty-one studies were conducted in Europe.[45, 58, 60, 71, 76, 77, 84, 85, 91, 104, 105, 113, 125, 127, 133, 136, 147, 169-172, 193, 201] Nineteen studies were conducted in Asia (including Turkey),[50, 63, 65-67, 69, 81-83, 89, 93, 106, 143, 145, 146, 155, 156, 191, 196] and 12 in North America (11 in the United States).[68, 70, 72, 79, 95, 101, 110, 118, 122, 126, 129, 132] Four studies were conducted in Egypt,[102, 154, 165, 192] and one each in New Zealand[98] and Brazil.[162] Study participants (n=6904) ranged in age from 6 months to 41 years (mean age in study under 18 years). Studies compared multiple techniques including coblation, cold dissection, electrocautery, laser, harmonic scalpel, and thermal welding, and the majority of studies reported only harms data. Twenty-one studies reported effectiveness data, chiefly time to return to normal diet or activity.[68, 77, 82, 85, 91, 93, 95, 105, 113, 118, 126, 129, 132, 133, 136, 146, 154, 165, 171, 172, 191, 193]

We considered 18 studies to have low risk of bias[45, 58, 71, 72, 77, 91, 95, 122, 125, 127, 133, 136, 146, 165, 169-172, 191, 201] 27 to have moderate risk,[50, 60, 65, 66, 68, 76, 81, 82, 84, 85, 89, 93, 98, 105, 113, 118, 126, 129, 132, 143, 147, 154, 156, 162, 192, 193, 196] and 13 to have high risk.[63, 67, 69, 70, 79, 83, 101, 102, 104, 106, 110, 145, 155]

Table 24. Overview of studies comparing surgical techniques for tonsillectomy

Characteristic	RCTs	Nonrandomized Trials	Prospective Cohort Studies	Total Literature
Comparisons				
Coblation vs. Cold Techniques	6	1	0	7
Coblation vs. Electrocautery	7	0	0	7
Coblation vs. Laser	2	0	0	2
Cold Techniques vs. Electrocautery	11	2	1	14
Cold Techniques vs. Harmonic Scalpel	4	0	0	4
Cold Techniques vs. Laser	2	0	0	2
Cold Techniques vs. Thermal Welding	3	0	0	3
Electrocautery vs. Electrocautery	1	1	0	2
Electrocautery vs. Harmonic Scalpel	5	0	0	5
Other*	12	0	0	12
Study Characteristics				
Allocates Intervention by Tonsil	8	2	0	10
Assesses Total Tonsillectomy	50	4	1	55
Assesses Partial Tonsillectomy	3	0	0	3
Surgical Indication				
Throat Infection	6	3	0	9
OSDB	7	0	0	7
OSDB+Throat Infection	27	1	0	28
Not specified	13	0	1	14
Effectiveness Outcomes Frequently Reported				
Time to Return to Normal Diet	14	1	0	15
Time to Return to Normal Activity	6	1	0	7
Risk of Bias				
Low	16	1	1	18
Moderate	24	3	0	27
High	13	0	0	13
Total N participants	**6366**	**478**	**60**	**6904**

*Includes comparisons of 3 techniques;[45, 79, 84, 101, 165] cold techniques vs. other cold techniques[58] or molecular resonance;[85] electrocautery vs. laser[113] or molecular resonance,[66] or unspecified tonsillectomy;[143] coblation vs. molecular resonance;[76] and laser vs. other lasers.[60]

N = number; OSDB = obstructive sleep-disordered breathing; RCT = randomized controlled trial

Detailed Analysis

As noted, most studies reported harms data (see Harms of Tonsillectomy section below). Nineteen studies (17 RCTs and 1 nonrandomized trial)—eight with low[77, 91, 95, 133, 136, 146, 165, 171, 172]and 11 with moderate risk of bias[68, 82, 93, 105, 113, 118, 126, 129, 132, 154, 193]—reported on return to normal diet or activity—the only usable effectiveness outcomes reported.

Findings By Surgical Comparison

Coblation vs. Cold Dissection Tonsillectomy

Five RCTs (4 low[91, 95, 146, 171, 172] and 1 moderate[77] risk of bias) and one nonrandomized trial with moderate risk of bias[193] compared coblation and cold dissection tonsillectomy (Table 25). Across these small, short-term studies, coblation tonsillectomy was generally associated with faster recovery. Four studies reported on return to normal diet, with mixed results. In two low

risk of bias studies, children receiving coblation tonsillectomy returned to normal diet sooner (roughly 2-3 days) than those undergoing cold dissection;[91, 146] in two other studies (one low, one moderate risk of bias), differences were not significant between groups.[77, 95] Return to normal activity occurred significantly earlier after coblation in three low risk of bias studies.[91, 146, 171, 172] In one moderate risk of bias nonrandomized study, children undergoing coblation tonsillectomy had fewer post-procedure school absences than those receiving cold dissection (mean 5.3 vs. 8.9 days, p<0.001).[193]

Table 25. Return to normal diet and activity in studies comparing coblation and cold dissection tonsillectomy

Author, Year Study Type Risk of Bias	Comparison Groups (n)	Return to Normal Diet or Activity
Omrani 2012[146] RCT Low RoB	G1: Coblation tonsillectomy(47) G2: Cold dissection Tonsillectomy (47)	**Time to return to normal diet, mean days ± SD** G1: 6.27 ± 1.07 G2: 9.25 ± 1.3 G1 vs. G2: p < 0.0001 **Time to return to normal activity, mean days ± SD** G1: 7.63 ± 1.16 G2: 11.7 ± 1.68 G1 vs. G2: p < 0.0001
Roje 2009[171, 172] RCT Low RoB	G1: Coblation tonsillectomy (50) G2: Cold dissection tonsillectomy (50)	**Time to return to normal activity, mean days (range)** G1: 2 (1-7) G2: 4 (1-9) G1 vs. G2: p < 0.001
Parker 2009[77] RCT Moderate RoB	G1: Coblation tonsillectomy (35) G2: Cold steel tonsillectomy (35)	**Return to normal diet, days** Data reported only in figures G1 vs.G2: p=NS
Di Rienzo Businco 2008[193] Nonrandomized trial Moderate RoB	G1: Coblation tonsillectomy (21) G2: Cold dissection tonsillectomy (21)	**Days absent from school post-procedure, mean±SD** G1: 5.3 ± 1.7 G2: 8.9 ± 1.5 G1 vs. G2: p<0.001
Shapiro 2007[95] RCT Low RoB	G1: Coblation tonsillectomy (23) G2: Cold dissection tonsillectomy (23)	**Time to return to normal diet, mean days** G1: 4 G2: 3 G1 vs. G2: p = NS
Mitic 2007[91] RCT Low RoB	G1: Coblation tonsillectomy (20) G2: Cold dissection tonsillectomy (20)	**Expected postoperative day to achieve normal diet** G1: 6.80 G2: 8.93 G1 vs. G2: p<0.001 **Expected postoperative day to achieve normal activity** G1: 6.62 G2: 8.45 G1 vs. G2: p<0.001

G=group; N=number; NS=not significant; RoB=risk of bias

Electrocautery vs. Cold Dissection Tonsillectomy

Electrocautery was generally associated with more favorable results in three small RCTs addressing this comparison (one with low[136] and 2 with moderate risk of bias[81, 129]) (Table 26). Electrocautery was superior to cold dissection in a faster return to normal diet in two studies[81, 136]

and did not differ in the third.[129] Return to activity was significantly faster in the electrocautery arm in one study,[136] but no different in two others.[81, 129]

Table 26. Return to normal diet and activity in studies comparing electrocautery and cold dissection tonsillectomy

Author, Year Study Type Risk of Bias (RoB)	Comparison Groups (n)	Return to Normal Diet or Activity
Nunez 2000[136] RCT Low RoB	G1: Electrocautery tonsillectomy (24) G2: Cold dissection tonsillectomy (26)	**Time to return to normal diet, median days (95% CI)** G1: 7.5 (5-8) G2: 5 (3-7) G1 vs. G2: p < 0.05 **Time to return to normal activity, median days (95% CI)** G1: 7 (5-8) G2: 5 (3-8) G1 vs. G2: p < 0.05
Hesham 2009[81] RCT Moderate RoB	G1: Electrocautery tonsillectomy (71) G2: Cold dissection tonsillectomy (69)	**Mean % of normal diet resumed (POD1), mean ± SD** G1: 54.67 ± 13.69 G2: 48.53 ± 21.54 G1 vs.G2: p <0.05 **Mean % of normal diet resumed (POD7), mean ± SD** G1: 84 ± 19 G2: 91.3 ± 14.17 G1 vs.G2: p <0.05 **Mean % of normal activity resumed (POD1), mean ± SD** G1: 73.33 ± 19.68 G2: 78.13 ± 16.9 G1 vs. G2: p=NS **Mean % of normal activity resumed (POD7), mean ± SD** G1: 92.67 ± 14.92 G2: 96 ± 7.17 G1 vs. G2: p=NS
Young 2001[129] RCT Moderate RoB	G1: Electrocautery tonsillectomy (26) G2: Cold dissection tonsillectomy (31)	**Time to return to normal diet and activity** G1 vs.G2: p=NS

G=group; N=number; NS=not significant; POD=postoperative day; RoB=risk of bias

Coblation vs. Electrocautery Tonsillectomy

Four RCTs with moderate risk of bias compared coblation and electrocautery tonsillectomy with mixed results (Table 27).[68, 118, 126, 133] Children undergoing coblation returned to normal diet more quickly than those undergoing electrocautery tonsillectomy in two studies,[68, 133] but recovery did not differ significantly between groups in two others.[118, 126] Children undergoing coblation also returned to normal activity roughly two days more quickly than those receiving electrocautery in two studies.[118, 126]

Table 27. Return to normal diet and activity in studies comparing coblation and electrocautery tonsillectomy

Author, Year Study Type Risk of Bias (RoB)	Comparison Groups (n)	Return to Normal Diet or Activity
Temple 2001[133] RCT Low RoB	G1: Coblation tonsillectomy (18) G2: Electrocautery tonsillectomy (20)	**Time to return to normal diet, mean days** G1: 2.4 G2: 7.6 G1 vs. G2: p < 0.0001
Parker 2011[68] RCT Moderate RoB	G1: Coblation tonsillectomy (40) G2: Electrocautery tonsillectomy (40)	**Time to return to normal diet, mean days** G1: 5.2 G2: 6.2 G1 vs.G2: p=0.04
Stoker 2004[118] RCT Moderate RoB	G1: Coblation tonsillectomy (44) G2: Electrocautery tonsillectomy (45)	**Time to return to normal diet, mean days ± SD** G1: 4.6 ± 2.1 G2: 5.2 ± 2 G1 vs. G2: p = NS **Time to return to normal activity, mean days ± SD** G1: 7.4 ± 1.9 G2: 6.7 ± 1.8 G1 vs. G2: p = NS
Shah 2002[126] RCT Moderate RoB	G1: Coblation tonsillectomy (17) G2: Electrocautery tonsillectomy (17)	**Time to return to normal diet for >50% of participants** G1: within 7 days postoperatively G2: >10 days postoperatively G1 vs.G2: p=NS **Time to return to normal activity for >50% of participants** G1: 8 days postoperatively G2: 10 days postoperatively G1 vs.G2: p=NR **Parental return to work** G1 vs. G2: p=NS

G=group; N=number; NR=not reported; NS=not significant; POD=postoperative day; RoB=risk of bias

Harmonic Scalpel vs. Other Tonsillectomy Techniques

Three RCTs with moderate risk of bias evaluated tonsillectomy with a harmonic scalpel (which uses ultrasonic frequency to cut and cauterize tissue) compared with electrocautery,[132] coblation,[154] or cold dissection[105] (Table 28). Studies compared different measures of recovery, thus limiting our ability to draw conclusions about differences in effectiveness. In the most recent RCT, children who had harmonic scalpel tonsillectomy returned to school after surgery in a median of 6 days compared with 8 who had coblation (p=NR). Another RCT comparing harmonic scalpel and cold dissection reported "dietary intake scores" ranging from zero to 3, with a score of zero indicating fluids only and a score of 3 indicating fluids plus normal diet.[105] Children in the harmonic scalpel group had better dietary scores at each postoperative measurement (days 1, 3, 5, 7, 9), but scores in both groups declined over time. A final RCT reported the number of children returning to normal diet and activity.[132] Significantly more children in the harmonic scalpel group returned to normal diet or activity compared with children undergoing electrocautery at postoperative day 1 and day 3.

Table 28. Return to normal diet and activity in studies comparing harmonic scalpel and other techniques for tonsillectomy

Author, Year Study Type Risk of Bias (RoB)	Comparison Groups (n)	Return to Normal Diet or Activity
Salama 2012[154] RCT Moderate RoB	G1: Harmonic scalpel tonsillectomy (75) G2: Coblation tonsillectomy (75)	**Days to return to school post-tonsillectomy, median** G1: 6 G2: 8
Oko 2005[105] RCT Moderate RoB	G1: Harmonic scalpel tonsillectomy (45) G2: Cold dissection (48)	**Dietary intake scores, median (range)** POD1 G1: 1 (0-1) G2: 0 (0-1) G1 vs. G2: p<0.0001 POD9 G1: 0 (0-1) G2: 0 (0-1) G1 vs. G2: p=0.006
Walker 2001[132] RCT Moderate RoB	G1: Harmonic scalpel tonsillectomy (97) G2: Electrocautery tonsillectomy (75)	**N returned to normal diet by POD1** G1: 43 (44.3) G2: 17 (22.7) G1 vs. G2: p = 0.004 **N returned to normal diet by POD3** G1: 72 (74.2) G2: 35 (46.7) G1 vs. G2: p = 0.001 **N returned to normal activity by POD1** G1: 27 (27.8) G2: 9 (12) G1 vs. G2: p = 0.011 **N returned to normal activity by POD3** G1: 48 (49.5) G2: 17 (22.7) G1 vs. G2: p = 0.001

G=group; N=number; NR=not reported; POD=postoperative day; RoB=risk of bias

Laser vs. Coblation and/or Cold Dissection Tonsillectomy

Only two small RCTs addressed laser and did not provide sufficient data to draw conclusions about effectiveness compared with more standard techniques (Table 29). Two RCTs with low[165] and moderate[93] risk of bias comparing either potassium titanyl phosphate (KTP) laser or diode laser tonsillectomy to coblation and/or cold dissection reported no significant group differences in time to return to normal diet.

Table 29. Return to normal diet and activity in studies comparing laser and coblation and/or cold dissection for tonsillectomy

Author, Year Study Type Risk of Bias (RoB)	Comparison Groups (n)	Return to Normal Diet or Activity
Elabdawey 2015[165] RCT G1: Coblation tonsillectomy (40) G2: Cold dissection tonsillectomy (40) G3: Diode laser tonsillectomy (40) Low RoB	G1: Laser tonsillectomy (40) G3: Coblation tonsillectomy (40) G2: Cold dissection tonsillectomy (40)	**Time to return to normal diet, mean day** G1: 5 G2: 4 G3: 4 G1 vs.G2 vs.G3: p = NS
Hegazy 2008[93] RCT Moderate RoB	G1: Laser tonsillectomy (40) G2: Coblation tonsillectomy (40)	**Time to return to normal diet or activity** G1 vs.G2: p = NS

G=group; N=number; NS=not significant; RoB=risk of bias

Thermal Welding vs. Cold Dissection and/or Electrocautery Tonsillectomy

Two studies compared thermal welding tonsillectomy (a newer tonsillectomy technique which uses heated forceps to cut and cauterize tissue) and either cold dissection[82] or cold dissection and electrocautery (Table 30).[191] Studies reported different measures, which limits our ability to draw conclusions. The RCT comparing thermal welding and cold dissection (moderate risk of bias) reported no differences in return to normal activity (mean of 5 days post-tonsillectomy).[82] Time to return to normal diet was lowest in the cold dissection group followed by thermal welding ($p<0.001$) followed by the electrocautery arm in the nonrandomized trial.[191]

Table 30. Return to normal diet and activity in studies comparing thermal welding and other techniques for tonsillectomy

Author, Year Study Type Risk of Bias (RoB)	Comparison Groups (n)	Return to Normal Diet or Activity
Ozkiris 2012[191] Nonrandomized trial Low RoB	G1: Thermal welding tonsillectomy (104) G2: Cold dissection tonsillectomy (99) G3: Electrocautery tonsillectomy (102)	**Time to return to normal diet, mean days ± SD (range)** G1: 7.3 ± 0.7 (7-9) G2: 7 ± 1.5 (6-9) G3: 9.3 ± 1.7 (9-11) G1 vs.G2: p < 0.001 Other p values=NR
Sezen 2008[82] RCT Moderate RoB	G1: Thermal welding tonsillectomy (25) G2: Cold dissection tonsillectomy (25)	**Time to return to normal activity, mean days** G1+G2: 5 G1 vs.G2: p = NS

G = group; N = number, NR = not reported; NS = not significant; ROB = risk of bias

Harms of Tonsillectomy

Key Points

- Strength of evidence is high for low rates of post-tonsillectomy hemorrhage (PTH) and utilization harms across surgical techniques.

- In meta-analyses, rates of primary and secondary PTH associated with total and partial tonsillectomy were consistently low, below 4 percent for any technique and with overlapping confidence bounds. Overall, estimates of PTH and utilization harms associated with tonsillectomy are low.
- Pooled rates (without adjustment) of PTH were low overall (3.5% in total tonsillectomy; 1.2% in partial tonsillectomy) in comparative studies. Unadjusted rates of revisits for pain, dehydration, or postoperative nausea and vomiting (PONV) were also low (< 2%).
- Other harms were disparate and generally not clinically significant. No comparative studies reported deaths.
- Rate of harms in case series and database or registry studies were consistent with rates from comparative studies. Three deaths were reported in case series including 1292993 children.

Overview of the Literature

In order to fully account for potential harms of tonsillectomy, primarily PTH, readmission and reoperation, we compiled all comparative studies and examined rates of harms by arm, then reviewed case series and database studies, which were not included in the effectiveness analysis. We did not assess harms separately by indication because there is no reason to expect that they would differ; therefore, we do not separate them into the KQ1 and KQ2 results sections but combine surgical harms here.

We present the data obtained from comparative studies that were generally of higher quality followed by that of the case series and database studies and comment on their consistency. Finally, we conducted a Bayesian meta-analysis to estimate predicted rates of primary PTH, secondary PTH, reoperation and readmission by partial and total tonsillectomy, and by surgical approach.

Comparative Study Arms Reporting PTH or Other Harms Data

One-hundred and three comparative studies of low or moderate risk of bias reported harms data.[9, 11, 40-43, 45-47, 49-51, 54-56, 58-62, 65, 66, 68, 71, 73, 76, 77, 80-82, 84, 86-89, 91-93, 95, 97, 98, 100, 105, 107-110, 112-114, 116-119, 121-127, 129, 130, 132-134, 136, 138, 140, 141, 143, 146, 147, 150, 152-157, 160, 162, 163, 165-174, 176-180, 184-196, 201, 205, 206, 262]

Most studies (n=86) reported PTH-related outcomes including number of post-tonsillectomy hemorrhages, which may have been reported as primary (generally defined as occurring within 24 hours of surgery), secondary (generally defined as occurring more than 24 hours postoperatively), or at an undefined or unspecified time.[9, 40, 42, 43, 45-47, 49, 50, 55, 56, 58-62, 65, 66, 68, 71, 73, 76, 77, 80-82, 84, 86-89, 91-93, 95, 97, 98, 100, 105, 107, 108, 110, 112-114, 117-119, 121, 122, 125-127, 129, 132, 133, 136, 140, 141, 143, 146, 147, 150, 152-155, 160, 162, 163, 165-180, 184-196, 201] Other frequently reported harms in comparative studies (n=32) included revisits or readmissions for postoperative pain, dehydration, or PONV.[41, 45, 54, 68, 71, 76, 87, 95, 100, 105, 109, 113, 114, 116, 118, 121, 123-127, 132, 136, 141, 150, 156, 166-168, 173-180, 187, 188, 201, 205, 206]

Twenty-four studies also reported other non-PTH harms of surgical procedures.[9, 11, 45, 46, 56, 60, 71, 72, 87, 109, 113, 114, 116, 122, 126, 127, 132, 147, 160, 192, 194, 201, 206, 263]

We present detailed harms tables in Appendix H. The tables in this appendix report pooled rates of harms without adjustment, typically presented by technique (e.g., coblation, cold dissection), type (partial or total tonsillectomy), and indication (OSDB, throat infection, mixed [OSDB and throat infection], or unspecified) where possible.

Studies Reporting Harms Combined in Meta-Analysis

Seventy studies contributed data to the meta-analysis (63 RCTs,[45, 46, 50, 55, 58, 60, 63, 65-68, 71, 73, 76, 77, 79, 81-88, 91-93, 95, 97-102, 104-106, 110, 112, 113, 118, 122, 125-127, 129, 131-133, 136, 141, 143, 145-147, 153-155, 160, 162, 165, 171, 172, 184-186] 6 nonrandomized trials,[189, 191-194, 196] and 1 prospective cohort study[201]). We included study arms in the meta-analysis if they evaluated total (68 arms[45, 46, 50, 55, 58, 63, 65-68, 71, 73, 76, 77, 79, 81-88, 91-93, 95, 97, 98, 100-102, 104, 105, 110, 112, 113, 118, 122, 125-127, 129, 131-133, 136, 141, 143, 145-147, 153-155, 160, 162, 165, 171, 172, 184-186, 189, 191-194, 196, 201, 262]) or partial tonsillectomy (18 arms[55, 60, 73, 86-88, 92, 97, 100, 112, 131, 141, 145, 153, 160, 184-186, 189, 194]). The resulting subset of studies included the following tonsillectomy techniques: cold dissection, electrocautery, coblation, harmonic scalpel, laser, molecular resonance, thermal welding, and microdebrider. We further partitioned data based on PTH outcomes, and included primary (occurring within 24 hours of surgery) PTH (20 studies, 42 arms), secondary (occurring >24 hours post-surgery) PTH (27 studies, 56 arms), non-operative readmission associated with PTH (17 studies, 34 arms), and reoperation associated with PTH (27 studies, 57 arms).

Twenty-two studies included in the meta-analysis had low risk of bias;[45, 55, 58, 68, 71, 77, 91, 92, 95, 99, 100, 122, 125, 127, 133, 136, 146, 153, 165, 171, 172, 191, 201] 36 had moderate risk,[46, 50, 60, 65, 66, 73, 76, 81, 82, 84-88, 93, 97, 98, 105, 112, 113, 118, 126, 129, 132, 141, 143, 147, 154, 160, 162, 184-186, 189, 192-194, 196] and 12 had high risk.[63, 67, 79, 83, 101, 102, 104, 106, 110, 131, 145, 155] As noted, in sensitivity analyses, high risk of bias studies did not affect findings, so we included them in final analyses.

Case Series and Database Studies Reporting Harms

In addition, we sought PTH rates in case series and database analyses to determine whether they supported findings in the comparative literature, and to assess harms in larger study populations. We identified 41 unique database or registry studies or case series with ≥ 1000 children (reported in 50 papers) addressing PTH or other harms including readmissions or revisits for dehydration or nausea.[21, 207-213, 215-254, 264 360, 265] Most studies (n=19) were conducted in Europe;[207, 209, 210, 214, 216-218, 220-222, 225-227, 228 , 231, 233, 235, 236, 240, 242, 247, 248, 250, 252, 253, 265] 16 were conducted in North America;[21, 208, 211, 213, 215, 219, 223, 224, 229, 230, 232, 237, 241, 243-246, 254] four in Asia;[212, 234, 249, 251] and two in Australia or New Zealand.[238, 239] We rated 13 studies as low risk of bias[21, 207-210, 214, 216-230, 232, 237, 238, 249]and 23 as moderate.[211-213, 215, 231, 233-236, 239-248, 250-254, 265] We considered five studies[207, 232, 237, 238, 249] to have a high risk of bias and do not present them in the detailed analysis.

Twenty-three studies were case series and 18 were database or registry studies. Studies included a total of 1,292,993 children, with numbers of participants ranging from 1,109 to over 139,000 across studies. Most studies (n=26) reported generally on PTH or other sequelae of tonsillectomy without specifying surgical technique.[21, 207-210, 214-219, 229, 230, 232, 233, 235, 237-240, 242-249] Eleven studies reported PTH or other harms by surgical technique or instrument,[213, 220-222, 225-228, 234, 236, 241, 250-254, 265] three reported specifically on PTH related to dexamethasone use,[211, 212, 224] and four reported PTH rates by surgical indication and technique,[212, 227, 228, 231, 254] and one reported readmission data by comorbidity.[233]

PTH was reported in nearly all studies. Nine studies reported on readmission for non-PTH indications.[21, 213, 215, 219, 223, 224, 230, 231, 239, 240, 266] Eleven studies reported mortality or other harms.[208, 213, 215, 225, 226, 229, 233, 240, 247, 248, 250, 252, 253, 265] Appendix H provides more details on harms reported in each study and tables of unadjusted pooled rates of PTH and other harms.

Detailed Analysis

Unadjusted PTH-Related Outcomes in Comparative Studies Addressing Tonsillectomy

Total Tonsillectomy

Sixty-two unique comparative studies of low or moderate risk of bias (106 arms) reported postoperative PTH.[9, 45, 46, 50, 55, 58, 65, 66, 68, 71, 73, 76, 77, 81, 82, 84, 86, 88, 89, 91-93, 95, 97, 98, 100, 105, 110, 112, 113, 118, 122, 125-127, 129, 132, 133, 136, 141, 143, 146, 147, 153-155, 160, 162, 165-168, 171-180, 187-189, 191-194, 196, 201, 205, 206] We first present unadjusted rates of PTH. The 8160 children across studies who were treated with total tonsillectomy experienced 278 episodes (3.4%) of PTH (Table 31). Among these episodes, 32 were primary (typically occurring within 24 hours of tonsillectomy), 179 were secondary (occurring more than 24 hours post-tonsillectomy), and for 67, timing was not specified. Few children required reoperation to control PTH (n=78/8160), and 68 had nonoperative revisits or readmissions for PTH. Children undergoing tonsillectomy with harmonic scalpel had the highest rate of PTH (11%), although few children underwent this procedure (n=397). Few children also had laser tonsillectomy (n=189), with 5.3 percent experiencing PTH. Rates were similar among techniques that are more commonly used: cold dissection had a rate of 3.9 percent; electrocautery had a rate of 3.4 percent; and coblation had a rate of 2.5 percent. Rates of revisits and reoperations overall were low, typically less than 6 percent. Tables in Appendix H outline rates associated with each technique in each study arm.

Table 31. Unadjusted PTH-related outcome rates in study arms evaluating total tonsillectomy

Technique (N arms)	Total N	Total PTH (%)	Total Primary PTH (%)	Total Secondary PTH (%)	Total Unspecified PTH (%)	Total Nonoperative Revisits/ Readmissions for PTH (%)	Total Reoperations for PTH (%)
All arms (106)	8118	278 (3.4)	32 (0.72)	179 (2.9)	67 (0.84)	68 (2.5)	78 (1.8)
Electrocautery (30)	2603	89 (3.4)	5 (0.30)	71 (3.1)	13 (0.50)	20 (4.0)	25 (2.2)
Cold dissection (34)	1957	72 (3.7)	6 (0.61)	55 (3.2)	11 (0.58)	11 (1.5)	18 (2.1)
Unspecified/ other technique (7)	1589	37 (2.4)	9 (1.3)	0	28 (1.8)	8 (2.0)	21 (1.7)
Coblation (18)	758	18 (2.4)	2 (0.54)	7 (1.6)	9 (1.3)	5 (1.3)	3 (0.93)
Molecular resonance (4)	426	2 (0.47)	0	0	2 (0.47)	0	0
Harmonic scalpel (5)	397	45 (11.3)	1 (0.30)	38 (11.3)	6 (1.5)	15 (5.5)	8 (3.1)
Thermal welding (4)	199	5 (2.5)	0	5 (2.5)	0	0	0
Laser (4)	189	10 (5.3)	9 (6.0)	1 (0.91)	0	9 (6.0)	3 (2.0)

Note: Percents for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = Number; PTH = Post-Tonsillectomy Hemorrhage

Partial Tonsillectomy

PTH rates did not exceed 3 percent among the 20 study arms contributing data to assess bleeding in partial tonsillectomy (Table 32).[55, 60, 73, 86-88, 92, 97, 100, 112, 141, 153, 160, 169, 170, 185-189, 194, 267] Rates were highest for coblation tonsillectomy (2.7%). No PTH was associated with laser approaches, but few studies assessed this modality.[60, 169, 170]

Table 32. Unadjusted PTH-related outcome rates in study arms evaluating partial tonsillectomy

Technique (n arms)	Total N	Total PTH (%)	Total Primary PTH (%)	Total Secondary PTH (%)	Total Undefined PTH (%)	Total Nonoperative Revisits/ Readmissions for PTH (%)	Total Reoperations for PTH (%)
All arms (20)	930	11 (1.2)	2 (0.26)	1 (0.14)	8 (0.93)	6 (1.4)	3 (0.55)
Coblation (7)	257	7 (2.7)	2 (1.6)	1 (0.98)	4 (2.2)	5 (2.9)	1 (0.74)
Microdebrider (5)	252	2 (0.79)	0	0	2 (1.2)	1 (0.98)	1 (0.43)
Cold dissection (4)	124	1 (0.81)	0	0	1 (2.5)	0	1 (0.81)
Other/ Unspecified (1)	243	1 (0.41)	0	0	1 (0.41)	0	0
Laser (3)	54	0	0	0	0	0	0

Note: Percents for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = Number; PTH = Post-Tonsillectomy Hemorrhage

PTH by Indication

Across all techniques and types of tonsillectomy (partial vs. total), the overall rate of PTH after surgery was lowest for children with OSDB. Rates for children with throat infection or mixed or unspecified indications were similar (Table 33).

Table 33. Unadjusted PTH-related outcome rates by indication in study arms evaluating total or partial tonsillectomy

Indication (n arms)	Total N	Total PTH (%)	Total Primary PTH (%)	Total Secondary PTH (%)	Total Undefined PTH (%)	Total Nonoperative Revisits/ Readmissions for PTH (%)	Total Reoperations for PTH (%)
OSDB (33)	2467	48 (1.9)	5 (0.38)	17 (1.1)	26 (1.1)	17 (1.7)	15 (0.92)
Throat infection (28)	2594	88 (3.4)	12 (0.52)	71 (2.7)	5 (0.19)	32 (2.7)	10 (0.90)
Mixed (32)	2061	75 (3.6)	3 (0.86)	56 (3.4)	16 (0.81)	3 (0.94)	30 (3.4)
Unspecified (34)	1932	79 (4.1)	15 (1.2)	35 (2.8)	29 (1.8)	26 (2.8)	27 (2.0)

Note: Percents for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = Number; PTH = Post-Tonsillectomy Hemorrhage

Revisits for Pain, Dehydration or PONV Following Tonsillectomy Reported in Comparative Studies

Rates of revisits for pain, dehydration, or PONV were typically less than 10 percent (Table 34). Eight studies reported zero revisits for non-PTH indications associated with one or both interventions studied.[54, 95, 116, 121, 123, 127, 136, 150] Two studies reported rates above 10 percent (see Appendix H for full details).[118, 125] One RCT comparing KTP laser and cold dissection total tonsillectomy as day-stay procedures reported 25 total admissions for pain (13 for cold dissection and 12 in laser) and 29 for vomiting (16 in cold dissection arm and 13 in laser) on the day of surgery.[125]In another RCT comparing electrocautery and coblation tonsillectomy, revisits comprised both return visits and phone calls to the provider; thus, rates are higher than those reported in other studies.[118]

Table 34. Unadjusted revisits for pain, dehydration, or PONV reported after tonsillectomy in arms of comparative studies

Technique (N arms)	Total Arm N	Pain Revisits/ Readmissions, n (%)	Dehydration Revisits/ Readmissions, n (%)	PONV Revisits/ Readmissions, n (%)	Other Revisits/ Readmissions, n (%)
All arms (38)	3030	45 (1.5)	40 (1.3)	45 (1.5)	3 (0.09)
Electrocautery-total (12)	883	12 (7.3)	20 (2.3)	7 (5.1)	NR
Cold dissection-total (9)	622	14 (5.4)	1 (0.21)	16 (10.5)	NR
Unspecified tonsillectomy-total (5)	590	NR	10 (1.7)	5 (0.85)	NR
Molecular resonance-total (2)	362	NR	0	NR	NR
Harmonic scalpel-total (2)	216	NR	2 (1.3)	NR	3 (4.9)
Coblation-total (5)	198	6 (8.8)	7 (3.5)	4 (9.8)	NR
Laser-total (3)	159	13 (10.1)	0	13 (16.5)	NR
Microdebrider-partial (2)	187	0	5 (2.5)	NR	NR
Coblation-partial (1)	34	NR	0	NR	NR

Note: Percents for readmissions/revisits reflect the number of each reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = Number, NR = Not Reported; PONV = Postoperative Nausea and Vomiting

Other Harms Following Tonsillectomy Reported in Comparative Studies

Twenty-four studies also reported other non-PTH harms of surgical procedures.[9, 11, 45, 46, 56, 60, 71, 72, 87, 109, 113, 114, 116, 122, 126, 127, 132, 147, 160, 192, 194, 201, 206, 263] Harms were largely minor and included burns or unspecified breathing complications (Table 35), and two studies including children with OSDB reported velopharyngeal insufficiency (VPI).[87, 126] One study noted that VPI resolved within two months,[87] and the other did not comment on resolution or severity.[126] Eight studies explicitly reported that no non-PTH harms occurred (not shown in table);[60, 72, 109, 122, 127, 147, 160, 201] Seven studies (15 arms) explicitly reported that no deaths occurred,[45, 56, 71, 76, 113, 132, 206]and two studies reported that no cases of VPI occurred.[109, 127]

Table 35. Other harms reported in studies of surgical techniques compared with medical treatment or other surgical techniques

Non-Bleeding Harms of Surgical Techniques	Number Of Studies (# Participants With Harm/Total Participants)	Reported Rates Across Studies
Electrocautery total tonsillectomy (scissors or forceps)		
Thermal burns in oral mucosa and tongue or other burns[192]	1 (14/91)	15%
Burn to thigh from improper grounding of electrocautery unit –hospitalized 3 days[116]	1 (1/21)	4.7%
Coblation total tonsillectomy		
VPI[87, 126]	2 (2/52)	2.8%-5.8%
Cold dissection partial tonsillectomy (scissors)		
Breathing complications[194]	1 (1/243)	0.4%
Other complications[194]	1 (0/243)	0%
Cold dissection total tonsillectomy		
Lip burn from cautery[114]	1 (1/57)	1.7%
Breathing complications[194]	1 (2/780)	0.2%
Other (unspecified) complications[194]	1 (1/780)	0.1%
CPAP		
Rash from mask[46]	1 (1/36)	2.7%
Total tonsillectomy (not specified)		
Complications from GABHS infection or medical treatment of infection (drug reaction, peritonsillar abscess, scarlet fever)[206]	1 (16/145)	5.7%
Erythematous rash from penicillin for throat infection[11]	1 (1/96)*	1%
Erythematous rash while receiving antimicrobial drug[9]	2 (4/190)*	2.1%

Note: 4 children in a no tonsillectomy arm also experienced erythematous rash while receiving penicillin in studies described in one publication,[11] and three children in non-surgical arms in another publication reporting 2 studies developed an antibiotic-associated erythematous rash.[9] The table notes one study reporting these outcomes as the publications combined data from each of the 2 studies reported in each paper and did not present harms data by study.
CPAP = Continuous Positive Airway Pressure

Meta-Analysis Results

Harms Associated With Total Tonsillectomy

Rates of primary PTH associated with total tonsillectomy in the meta-analysis were consistently low, all below 2 percent and with overlapping confidence bounds (Table 36). Electrocautery was associated with the highest rate of secondary PTH (occurring >24 hours post-procedure), with an estimate of 3.6 percent (95% Bayesian credible interval [BCI]: 2.0% to 5.4%). Rates of readmission ranged from 0 percent to 6 percent. Although laser was associated with the highest estimated risk of readmission, the confidence bounds were very wide. Overall, estimates of PTH and utilization harms associated with tonsillectomy are low.

Table 36. Rates of PTH and PTH-associated readmissions or revisits after total tonsillectomy

Technique	Primary PTH	Secondary PTH	Nonoperative Readmission	Reoperation
	%, 95% BCI			
Cold	0.07 (0.2 to 1.5)	3.2 (1.9 to 4.7)	2.8 (0.8 to 5.3)	1.2 (0.3 to 2.1)

Electrocautery	0.5 (0.1 to 1.1)	3.6 (2 to 5.4)	2.7 (0.6 to 5.2)	1.1 (0.3 to 1.9)
Coblation	1.3 (0.1 to 3.1)	1.9 (0.6 to 3.4)	1.4 (0.1 to 3.6)	1.2 (0.3 to 2.4)
Harmonic Scalpel	0.9 (0 to 2.6)	3.2 (1.2 to 5.7)	1.5 (0.3 to 3)	3.9 (1.5 to 6.6)
Laser	1.1 (0 to 5.3)	1.2 (0 to 3.5)	6 (0.8 to 14)	5.7 (0.2 to 17.1)
Molecular Resonance	0.4 (0 to 1.6)	0.6 (0 to 1.4)	0 (0 to 0.2)	0.8 (0 to 2.7)
Thermal Welding	5 (0 to 2)	3.7 (0.8 to 7.9)	2.7 (0 to 14.1)	0.3 (0 to 1.4)

BCI = Bayesian credible interval

Harms Associated With Partial Tonsillectomy

Primary bleeding associated with partial tonsillectomy was predicted to be below 3 percent regardless of technique, and secondary bleeding below 2 percent. Data on readmissions and reoperations were sparse; thus confidence bounds are very wide, and it is difficult to predict rates with any certainty (Table 37).

Table 37. Rates of PTH and PTH-associated readmissions or revisits after partial tonsillectomy

Technique	Primary PTH	Secondary PTH	Nonoperative Readmission	Reoperation
	%, 95% BCI			
Cold	1.6 (0.1 to 5.1)	0.8 (0 to 2.8)	4.1 (0.1 to 12.4)	0.5 (0 to 1.3)
Electrocautery	1.2 (0 to 4.1)	1 (0 to 3.2)	4 (0.1 to 12.2)	0.5 (0 to 1.3)
Coblation	2.1 (0.1 to 5.3)	0.4 (0 to 1.3)	1.4 (0.1 to 3.2)	0.5 (0 to 13)
Harmonic Scalpel	2.2 (0 to 8.2)	0.8 (0 to 3)	2.2 (0 to 6.7)	1.6 (0 to 4.5)
Laser	1.4 (0 to 6.7)	0.3 (0 to 1.2)	7.6 (0.1 to 23.5)	2 (0 to 6.5)
Molecular Resonance	0.9 (0 to 3.6)	0.2 (0 to 0.6)	0.1 (0 to 0.3)	0.3 (0 to 1.3)
Thermal Welding	1.1 (0 to 4.3)	1 (0 to 3.6)	3.6 (0 to 19.2)	1 (0 to 0.6)

BCI = Bayesian credible interval

Case Series and Database Analyses

Overall, 2 percent of children in case series experienced a PTH episode (Table 38). Unadjusted PTH rates in case series, database, or registry studies were generally in line with those reported in comparative studies (2% overall vs. 3.4% overall). Few children overall required readmission or reoperation for PTH (0.62% to 2%).

Few cases of revisits for pain, dehydration, or PONV (rates ranging from 1% to 7%) were reported in the nine studies providing such data. Three deaths were reported across case series or database studies. Other harms reported in these studies were disparate and typically not clinically significant (Appendix H).

Table 38. Unadjusted PTH rates reported across all studies

Author, Year RoB	Total N	Total PTH	Primary PTH, n (%)	Secondary PTH, n (%)	Unspecified PTH, n (%)	Nonoperative revisit or readmission for PTH, n (%)	Reoperation for PTH, n (%)

Author, Year RoB	Total N	Total PTH	Primary PTH, n (%)	Secondary PTH, n (%)	Unspecified PTH, n (%)	Nonoperative revisit or readmission for PTH, n (%)	Reoperation for PTH, n (%)
All studies	661851	13402 (2.02)	698 (1.1)	1319 (1.8)	11385 (1.8)	5356 (2.0)	1648 (0.62)
Database studies	488831	9962 (2.03)	111 (0.73)	290 (1.9)	9561 (2.0)	4814 (2.5)	1201 (0.55)
Case series	79925	2078 (2.6)	587 (1.5)	1029 (6.8)	74 (0.02)	392 (0.21)	540 (0.25)
Registry studies	110532	1750 (1.6)	NR	NR	1750 (1.6)	312 (0.68)	47 (0.10)

Key Question 5. Effectiveness of Perioperative Medications to Improve Outcomes

Key Points

- **S**trength of the evidence is low for reduced need for analgesia and for no effects on return to normal diet or activity with perioperative NSAIDs. It is also low for minimal PTH and associated utilization. Evidence is insufficient to assess non-bleeding related readmissions or revisits as few studies addressed these outcomes.
- Strength of evidence is low for a reduced need for analgesics or anti-emetics associated with steroids (IV or infiltrated dexamethasone). PTH and related utilization was low across studies (moderate strength of evidence for minimal bleeding). Evidence is insufficient to assess the effects of steroids on return to normal diet or activity. Evidence is also insufficient to assess non-bleeding related readmissions or revisits as few studies reported these outcomes.
- Strength of evidence is moderate for no effect of 5-HT perioperative anti-emetics on postoperative analgesia requirements and low for reduced need for postoperative anti-emetics given the small number of children evaluated in these studies.
- Some evidence suggests that perioperative dexamethasone and NSAIDs each decrease analgesic needs in the immediate postoperative period (post-anaesthesia care unit [PACU] and up to 24 hours).
- Perioperative administration of dexamethasone decreases need for rescue antiemetic medication use in the immediate postoperative period.
- Perioperative administration of 5-hydroxytryptamine (5-HT) receptor antagonists decreased the need for rescue antiemetic medication in the immediate postoperative period.
- Data are insufficient to assess the longer-term outcomes (>24 hours) of perioperative medication administration.

Overview of the Literature

Forty-eight studies (47 RCTs [41, 42, 44, 47-49, 52-54, 56, 59, 61, 64, 74, 75, 78, 80, 90, 94, 96, 107, 108, 111, 114, 115, 119-121, 123, 124, 128, 130, 134, 135, 137, 138, 142, 144, 148-152, 158, 159, 163, 164] and one nonrandomized trial[195]) involving 5864 children ranging in age from 1 to 18 years addressed perioperative medications (NSAIDs, steroids, anti-emetics, alone or in combination) for improving post-tonsillectomy outcomes (Table 39). Studies were primarily conducted in Asia (including China, India, Turkey, and Japan).[41, 47, 48, 52, 61, 64, 74, 75, 78, 107, 108, 111, 115, 119, 120, 123, 134, 135, 142, 148-152, 158, 159, 163, 164, 195] Six

studies were conducted in Europe,[59, 80, 96, 130, 137, 138] and six in North America (United States).[49, 56, 94, 114, 124, 128] Six studies were conducted in Africa,[42, 44, 53, 54, 121, 144] and one in Australia.[90]

Twenty-one studies had low risk of bias;[41, 42, 52-54, 56, 59, 61, 78, 90, 96, 107, 114, 115, 120, 121, 130, 134, 135, 137, 138, 148, 158] 23 had moderate; [44, 47-49, 64, 74, 80, 94, 108, 111, 119, 123, 124, 128, 144, 149-152, 159, 163]and four had high.[75, 142, 164, 195] Outcomes reported varied among studies: PTH, use of rescue medications, and use of rescue anti-emetics were most frequently reported.

Table 39. Overview of studies addressing perioperative pharmacologic agents to improve outcomes

Characteristic	NSAIDs	Steroids	Anti-emetics	Multi-agent therapy*	Total Literature
Study design					
RCT	13	16	5	13	47
Nonrandomized trial	0	1	0	0	1
Intervention Arms					
2	8	9	3	7	27
3	4	5	1	3	13
4	1	2	1	2	6
5	0	1	0	0	1
Surgical Indication					
Throat Infection	2	0	0	2	4
OSDB +Throat Infection	0	6	0	1	7
Unspecified	11	11	5	10	37
Key Effectiveness Outcomes Reported					
Rescue analgesics	7	12	1	11	31
Rescue antiemetics	1	12	2	7	22
Time to return to normal diet/activity	2	2	0	3	7
Health care utilization	0	0	0	0	0
Risk of Bias					
Low	3	8	5	7	23
Moderate	9	6	0	6	21
High	1	3	0	0	4
Total N participants	**1006**	**2312**	**931**	**1615**	**5864**

*Combination of drug classes. NSAIDs = non-steroidal anti-inflammatory drugs; OSDB = obstructive sleep-disordered breathing; RCT = randomized controlled trial

Detailed Analysis

Most studies addressed the outcomes of return to normal diet or activity or need for rescue medications, which we defined as the need for additional or higher doses of pain medications or anti-emetics beyond those given as part of the standard surgical protocol. We discuss findings by agent and key outcome below. Appendix H includes a detailed table of findings for each study.

NSAIDs

Return to Normal Diet and Activity

In two RCTs with moderate risk of bias comparing diclofenac suppository with or without other analgesics (acetaminophen plus tramadol) to lidocaine[74] or placebo,[128]time to normal activity or diet did not differ significantly between groups.

Need for Rescue Analgesics

Diclofenac

Analgesics. Two low [54, 158] and three moderate [74, 123, 151] risk of bias RCTs evaluated perioperative diclofenac. Two RCTs compared diclofenac suppository to placebo.[123, 158] In both, consumption of opioids was significantly lower in diclofenac groups. Another study comparing oral gabapentin, diclofenac suppository, and placebo found the mean 24h opioid consumption was equivalent in gabapentin and diclofenac groups but significantly less than placebo.[158]

Other trials were not placebo-controlled and had variable comparison groups. One that compared 2% viscous lidocaine post-tonsillectomy vs. diclofenac suppository reported no difference in analgesic need during the immediate 2 postoperative hours.[74] Another study comparing diclofenac suppository vs. intravenous [IV] pethidine found fewer children in the diclofenac arm required analgesia medication and used a significantly lower mean paracetamol dose in the first 24 postoperative hours.[151] A third trial compared triple analgesic regimen (diclofenac suppository, IV paracetamol, and IV tramadol) vs. placebo and reported that, in the immediate 4-6 postoperative period, no child in study group used rescue analgesia compared with 70 percent and 45 percent of controls who required rescue analgesia in the PACU and on the day surgery ward, respectively.[54]

Anti-emetics. A single moderate risk of bias study evaluated effectiveness of peritonsillar bupivacaine infiltration vs. diclofenac suppository reported no difference in antiemetic rescue use between arms.[163]

Ibuprofen

Analgesics. Three moderate risk of bias RCTs compared the effect of perioperative ibuprofen treatment vs. multiple different comparators and assessed postoperative analgesic requirements.[49, 108, 159] Two evaluated IV ibuprofen,[49, 159] while one used ibuprofen syrup.[108] One trial comparing IV paracetamol alone, IV paracetamol + mefenamic acid, and IV paracetamol + ibuprofen reported that over the 24 hour follow-up period, the ibuprofen group used significantly less postoperative analgesia than paracetamol alone.[159] A second trial compared single dose IV ibuprofen vs. placebo and assessed opioid use in the PACU.[49] In intent to treat analysis, percentage of opioid use did not differ between groups, mean number of rescue opioid doses, or mean dose. Another trial compared ibuprofen syrup (administered 1 hour pre-operatively) + peri-tonsillar infiltrated epinephrine vs. infiltrated lidocaine with epinephrine and reported no differences in mean paracetamol dose between arms.[108]

Ketoprofen

Analgesics. Two low risk of bias RCTs evaluated the post-tonsillectomy analgesic use among patients treated with ketoprofen vs. placebo.[96, 130] Study results differed. In one trial, no difference was observed in mean dose or proportion of patients receiving analgesia between

those treated with IV ketoprofen at induction, IV ketoprofen after surgery, or placebo[130] Another RCT compared ketoprofen, tramadol, and placebo and reported that patient-controlled analgesia requests were significantly lower in the ketoprofen group. No difference was observed in 24 hour total opioid use.[96]

Lornoxicam

Analgesics. A single moderate risk of bias RCT compared IV lornoxicam, infiltrated lornoxicam, and placebo, reporting rescue diclofenac consumption during first 24 hours was significantly lower in the IV group compared with either infiltration or placebo group ($p<0.000$).[144] No difference was observed between infiltration and placebo.

Ketorolac

Analgesics. A single moderate risk of bias trial compared IV ketorolac vs. fentanyl and reported that fewer children in the ketorolac arm required rescue analgesia than in fentanyl arm (8% [n=2] vs. 28% [n=9]) in the immediate postoperative period in PACU.[119] No overall difference in use of rescue medications was observed the first 24-hours postoperatively.

Steroids

Return to Normal Diet and Activity

Two low risk of bias RCTs assessed whether steroids affected time to return to normal diet post-tonsillectomy.[114, 137] One comparing IV dexamethasone vs. placebo found that those treated with steroids were ingesting a significantly higher percentage of their normal diet than those in the placebo group on POD one.[114] A second trial comparing tropisetron and tropisetron + dexamethasone found no difference in the percentage of children returning to normal diet on POD one or five.[137]

A single low risk of bias RCT compared time to normal activity between children treated with IV dexamethasone vs. no steroid (both groups had peritonsillar infiltration of ropivacaine + clonidine) and found a non-significantly longer time to normal activity in the steroid group.[54]

Need for Rescue Medications

Dose Escalation Trials

Analgesics. Four low- and moderate-risk of bias RCTs evaluated the efficacy of escalating doses of dexamethasone on post-tonsillectomy analgesia requirements.[59, 80, 94, 115] Doses studied varied by trial, ranging from 0.05 to 1 mg/kg. Three of four trials of dexamethasone at escalating doses,[94]or escalating doses and placebo,[59] or doses of dexamethasone compared with ondansetron or placebo,[115] showed no differences in postoperative analgesic requirements by dose.[59, 94, 115]

In contrast, one placebo controlled dose-escalation trial showed that children who received dexamethasone required significantly less ibuprofen during 24 hour follow-up.[80] Higher doses of dexamethasone did not significantly alter ibuprofen requirements.

Anti-emetics. Two dexamethasone dose escalation trials assessed the postoperative need for antiemetic rescue.[59, 80] Both studies showed significantly reduced use in groups treated with dexamethasone vs. placebo. One compared dexamethasone 0.05, 0.15, or 0.5 mg/kg vs. placebo after induction of anesthesia and found the need for rescue antiemetic to be significantly less in

all steroid arms at 24 hour follow-up.[80] A second study comparing IV dexamethasone at 0.15 mg/kg, 0.5 mg/kg vs. placebo reported that the use of alizapride was significantly lower in the steroid groups than placebo. In contrast, the use of tropisetron did not differ between arms.[59]

IV Dexamethasone versus Placebo

Analgesics. Eight trials compared outcomes among children treated with IV dexamethasone vs. placebo.[52, 107, 111, 121, 128, 148-150] This included four low [52, 107, 121, 148] and four moderate[111, 128, 149, 150] risk of bias studies. Time of follow-up varied from assessment of PACU or surgical ward analgesic use,[52, 107, 121, 128, 148] to 24 hours postoperatively,[111, 149, 150] to 3 postoperative days.[128]The majority of studies found steroid treatment to significantly reduce postoperative analgesic requirements vs. placebo or other agents such as ropivacaine.[52, 121, 148-150] However, in three studies, no differences between those treated with dexamethasone or placebo were observed.[107, 111, 128]

Anti-emetics. Two of five placebo-controlled studies showed reduced antiemetic use in children treated with dexamethasone.[107, 111, 121, 128, 148] One trial comparing IV dexamethasone vs. placebo reported significantly lower 24 hour antiemetic requirement in the dexamethasone arm.[148] Another trial that compared IV dexamethasone and placebo found no difference in antiemetic use in the PACU, but did show significantly reduced 24 hour and overall antiemetic rescue use in steroid arm.[121]

In contrast, three trials demonstrated no difference in need for antiemetic rescue between dexamethasone and placebo. For example, one trial found no difference in PACU or day surgical ward use of rescue metoclopramide or ondansetron between groups.[107] A second trial comparing IV dexamethasone vs. placebo (both groups receiving peritonsillar infiltration of ropivacaine + clonidine) found no group differences in antiemetic rescue us in the first 4 hours postoperatively.[128] A third trial found no statistical difference in PACU need for rescue antiemetic.[111]

Dexamethasone vs. Other Comparators

Analgesics. Four RCTs including one low[61] and three moderate [44, 48, 64] risk of bias studies compared postoperative analgesic requirements between IV dexamethasone and other comparators. One found no difference in PACU or 24 hour follow-up doses of morphine or paracetamol between those treated with a single dose of IV dexamethasone vs. IV methylprednisolone.[61] Another trial that compared IV dexamethasone vs. oral gabapentin, vs. the combination for 18 hours post-tonsillectomy found that the combined treatment group had fewer rescue medication (pethidine) requirements.[44] Intravenous dexamethasone was compared with IV acetaminophen in another trial that observed no difference in meperidine usage during 24 hour followup. A fourth trial compared IV dexamethasone vs. IV ketamine vs. the combination vs. placebo and found the combined therapy group had no 24-hour postoperative analgesia requirements. Both the steroid and ketamine alone groups had lower analgesia needs than placebo.[64]

Anti-emetics. One trial comparing IV dexamethasone vs. IV methylprednisolone observed no difference in percentage of patients receiving antiemetic medications in the PACU.[61] Another study assessed effectiveness of IV dexamethasone + infiltrated ropivacaine vs. ropivacaine alone showed a significantly reduced rate of antiemetic use in the dexamethasone arm.[52] Another RCT

compared IV dexamethasone vs. ketamine vs. the combination, vs. placebo showed that all treatment groups had significantly lower antiemetic use (ondansetron) than placebo.[64]

IV versus Infiltrated Dexamethasone

Analgesics. Two low-risk of bias RCTs evaluated the efficacy of IV versus peritonsillar infiltrated dexamethasone with or without concomitant levobupivacaine among children undergoing tonsillectomy.[41, 53] Both found infiltrated dexamethasone to reduce postoperative analgesic requirements significantly.

Anti-emetics. A single RCT compared IV vs. infiltrated dexamethasone vs. placebo and found use of postoperative rescue anti-emetic medications was significantly lower in both steroid groups compared with placebo.[41] Investigators observed no differences between dexamethasone groups.

Infiltrated Dexamethasone versus Placebo

Analgesics. One moderate risk of bias trial compared dexamethasone infiltration, 0.25% levobupivacaine with epinephrine infiltration, and saline placebo.[47] The total doses of rescue analgesia was significantly fewer for dexamethasone than other groups at all time points during the first postoperative week.

Anti-Emetics

Need for Rescue Medications

Analgesics. Five RCTs (four low risk of bias[90, 120, 134, 135] and one moderate[124]) evaluated the effect of perioperative antiemetic use on post-tonsillectomy analgesic requirements. All studies evaluated 5-hydroxytryptamine (5-HT) receptor antagonists including ramosetron,[120, 135] granisetron,[134, 135] ondansetron,[90, 124] and dolasetron.[124] Antiemetic medications did not have any effect on pain control in any trial.

Two compared different 5-HT antagonists. In one trial, children were randomized to IV granisetron vs. ramosetron at the end of surgery and demonstrated no difference in analgesics administered 24 hour postoperatively.[135]Another compared IV ondansetron vs. dolasetron, vs. placebo and found opioid use in the PACU did not differ between arms.

Two compared 5-HT antagonists to antiemetic from other classes including droperidol,[134] metoclopramide.[90, 134] In one trial that assessed the effectiveness of IV granisetron vs. droperidol vs. metoclopramide found no difference in analgesic use during 24 hour postoperatively.[134] Another RCT compared ondansetron vs. metoclopramide and also reported no difference in opioid use in the first 24 hours.[90]

One dose-escalating trial of ramosetron evaluated IV placebo vs. IV ramosetron at 3, 6, or 12 microgram/kg immediately after end of surgery.[120] It found no difference in 24 hour post-tonsillectomy analgesia use between groups.

Postoperative anti-emetics. Three studies including two low [120, 138] and one moderate [124] risk of bias RCTs assessed the effect of pre-emptive antiemetic use in reducing need for postoperative antiemetic rescue. Pre-emptive use of 5-HT receptor antagonists reduced the need for immediate postoperative anti-emetic use compared with placebo.

One study that compared IV tropisetron vs. placebo found significantly reduced 24 hour need for postoperative rescue-antiemetic use in the tropisetron arm (tropisetron 1/35, placebo 12/36,

p<0.01). A second trial assessed preoperative IV ondansetron vs. dolasetron vs. placebo with each group pretreated with dexamethasone.[124] Both 5-HT receptor antagonists had significantly less antiemetic rescue needs in PACU than placebo (ondansetron 4%, dolasetron 6%, placebo 22%, p<0.05). No child in any arm required antiemetic rescue in the 48 hours post-PACU. However, the overall antiemetic rescue requirement was significantly less overall for 5-HT receptor antagonists (ondansetron 4%, dolasetron 8%, placebo 24%, p<0.05). A third trial compared placebo vs. escalating ramosetron doses (3, 6, or 12 μg/kg).[120] Requirement for antiemetic rescue in first 24 hours were 30 percent for placebo, 25 percent for 3 μg/kg (p=NS), while none required rescue in higher dose ramosetron arms. Similarly, during 24-48 hour follow-up, 25 percent of placebo and 25 percent of the 3 μg/kg-ramosetron arm required rescue antiemetic, while none in higher dose arms needed it.

Harms Associated with Perioperative Medications

PTH

Seventeen studies provided data on PTH associated with perioperative medications for pain.[42, 47, 49, 56, 59, 61, 80, 107, 108, 114, 119, 121, 150, 152, 163, 268] Rates were low overall (3% to 9%), with higher PTH rates reported in patients who received steroids than those in other perioperative medications (Table 40).

Dexamethasone was the most commonly used steroid (9/10 studies).[47, 56, 59, 61, 80, 107, 114, 121, 150, 195] The tenth study used methylprednisolone.[61] Three steroid studies explicitly noted no PTH,[47, 61, 121] and three did not explicitly note number of bleeds but reported that no children receiving steroids had revisits or reoperation for PTH.[59, 107, 150] Another study did not explicitly note number of bleeds but reported that one child in the placebo and one in the steroid arm required reoperation.[114]

In one study comparing dexamethasone with placebo, 17 children in the steroid arm and 13 in the placebo arm had PTH (p=NR).[56] Revisits and reoperations differed significantly between groups, with more revisits occurring in the placebo arm (3.2% vs. 1.9%, p<0.001) but more reoperations for hemostasis in the steroid arm (1.9% vs. 0.6%, p=0.002). In another RCT comparing 3 doses of dexamethasone (0.05, 0.15, or 0.5 mg/kg) with placebo, dexamethasone decreased the incidence of PONV but increased the risk of PTH.[80] In total 22 children experienced 26 PTH episodes, which included any PTH, with or without evidence at clinical examination (placebo, n=2, dexamethasone 0.05 mg, n=6, dexamethasone 0.15 mg, n=2, and dexamethasone 0.5 mg, n=12, p=.003). The highest dose of dexamethasone was associated with the greatest PTH risk (adjusted RR compared with placebo=6.80; 95% CI: 1.77 to16.5. p=0.05). Eight children, all receiving steroids, required reoperation for hemostasis. In a third study comparing dexamethasone with placebo, two children in each arm had PTH requiring readmission but not reoperation for hemostasis.[195]

Few studies of NSAIDs (6 studies,[42, 49, 108, 119, 152, 163] 7 treatment arms) reported PTH (6 PTH in 277 treated children, 2.6%). Three cases of PTH were associated with diclofenac,[163] two with ibuprofen,[49] and one with ketorolac.[152] Two studies (one of ketorolac and one of lornoxicam) reported no cases of PTH.[42, 119]

Among arms addressing anesthetics (reported in two studies[47, 163]), four cases of PTH occurred with bupivacaine in one study,[163] and none with levobupivacaine.[47] No PTH was reported with non-NSAID analgesics (propacetamol, fentanyl) in the two studies addressing such agents.[119, 152]

Table 40. Unadjusted PTH-related outcomes in study arms evaluating perioperative medications for pain

Drug class (n arms)	Total N	Total PTH (%)	Total Primary PTH (%)	Total Secondary PTH (%)	Total Other/ Undefined PTH (%)	Total Non-operative Readmission or Revisit for PTH (%)	Total Re-operation for PTH (%)
All arms	1959	73 (3.7)	5 (0.27)	8 (0.47)	60 (3.2)	17 (1.1)	14 (0.83)
Steroids (15)	873	40 (4.6)	2 (0.23)	3 (0.34)	35 (4.0)	4 (0.61)	11 (1.4)
Placebo (13)	730	23 (3.2)	3 (0.43)	5 (0.91)	15 (0.80)	13 (0.85)	2 (0.12)
NSAIDs (7)	277	6 (2.6)	0	0	6 (2.6)	0	1 (1.4)
Anesthetics (2)	45	4 (8.9)	0	0	4 (16)	0	0
Non-NSAID Analgesics (3)	84	0	0	0	0	0	0

Note: Percents for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.

Concordance With Case Series and Database Studies

Three case series or database studies reported PTH associated with perioperative medications.[211, 212, 223, 224] One study evaluated differences in PTH requiring reoperation among children (≤ age 15) who had (n=1680) and had not (n=30254) received perioperative steroids (intravenous dexamethasone or hydrocortisone).[212] Most children had obstructive symptoms (over 65% in each arm), and 20 children in the steroid arm (1.2%) and 140 control children (0.5) had PTH requiring reoperation (p<0.001). Steroid use was associated with an increased rate of reoperation in children but not in adults in this study (OR for children=2.50, 95% CI: 1.47 to 4.23, p=0.001). Age was also noted as a risk factor in children (OR=1.10, 95% CI: 1.04 to 1.17, p<0.001) but the direction of effect was not clearly reported. Female children were also less likely to require reoperation than male (OR=0.73, 95%CI: 0.54 to 1.00, p=0.05).[212]

Another study evaluating adherence to 2011 AAO-HNS guideline recommendations related to perioperative dexamethasone and antibiotic use also reported PTH associated with these medications.[211] Out of all 15950 children (1-18 years of age) included in analyses, 432 experienced a PTH (2.7%). PTH occurred in 92 of 7432 children in the pre-guideline era (1.2%) and in 229 of 8518 children after guidelines were issued (2.7%). Differences between physicians or hospitals who did or did not use these medications perioperatively, either before or after the publication of guidelines, were not significant.

Another study assessed how well hospitals adhered to evidence-based process measures including use of perioperative dexamethasone and antibiotics using data from the Pediatric Health Information System database and reported a significantly greater risk of PTH-associated revisits in children who received dexamethasone (3.11%, 95% CI: 2.99% to 3.23%) compared with those who did not (2.71% , 95% CI: 2.50% to 2.91%; standardized difference=0.40%, 95% CI: 0.13% to 0.67%, p=0.003).

Revisits

Few studies evaluating perioperative agents reported any revisits for non-PTH indications[41, 54, 114, 121, 123, 150] (Table 41); in 8 of 11 study arms, no revisits or readmissions occurred. Higher, though still low, rates typically occurred with combination agents such as dexamethasone plus anti-emetics[124] or in placebo arms.[114, 124, 150] In one study comparing perioperative IV

dexamethasone with placebo, four children in the placebo arm (11%) were readmitted for dysphagia and throat pain compared with none in the dexamethasone arm (p=NR).[150]

Table 41. Unadjusted revisits or readmissions for pain, dehydration, and PONV reported in comparative study arms addressing perioperative agents

Drug Class (N arms)	Total Arm N	N Pain Revisits/ Readmissions (%)	N Dehydration Revisits/ Readmissions (%)	N PONV Revisits/ Readmissions (%)
All arms (11)	542	4 (1.1)	1 (0.33)	1 (0.26)
Steroids (5)	279	0	1 (1.6)	0
NSAIDs (1)	20	0	0	0
Anesthetic (1)	80	0	0	0
Placebo (4)	163	4 (6.9)	0	1 (1.4)

Note: Percents for readmissions/revisits reflect the number of each instance of reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = number; NSAID=non-steroidal anti-inflammatory drug; PONV = postoperative nausea and vomiting

Key Question 6. Effectiveness of Postoperative Medications to Reduce Pain-Related Outcomes After Tonsillectomy

Key Points

- Few studies addressed the same interventions and comparisons; thus, strength of the evidence for the effect of postoperative analgesics on need for rescue medications or return to normal diet or activity was insufficient. Strength of evidence is low for no difference in effects on return to normal diet or activity between steroids and placebo.
- Available data are conflicting as to whether postoperative use of NSAIDs (celecoxib, ibuprofen, diclofenac) decreases rescue pain medication requirement in the first 24-48 hours among children post-tonsillectomy. Longer-term effectiveness of these medications cannot be gleaned from currently available data.
- Return to normal diet or activity did not differ between groups in two studies comparing postoperative prednisolone and placebo.
- PTH rates overall were low. The total rate in steroid studies was higher, but numbers of PTH in steroid and placebo arms in the two studies addressing that comparison were similar. Rates in studies comparing NSAIDs (celecoxib, ibuprofen) and non-NSAID analgesics to placebo or other medications were also similar.

Overview of the Literature

Of 11 studies addressing postoperative medications for pain-related outcomes identified, ten were RCTs,[40, 43, 51, 57, 62, 117, 139, 140, 157, 161] and one was a nonrandomized trial (Table 42).[190] Study country of origin included New Zealand,[51, 62] Canada,[40, 157] Denmark,[139, 140] Serbia,[117] Egypt,[161] Jordan,[57] and South Korea.[43] Studies included a total of 2539 children ranging in age from 1 to 18 years.

Studies assessed four categories of postoperative medications: analgesics (n=8),[40, 51, 117, 139, 140, 157, 161, 190] steroids (n=2),[43, 62] and antibiotics (n=1)[57]. Specific analgesics considered included non-steroidal anti-inflammatory drugs (NSAID),[40, 51, 140, 157, 161, 190] acetaminophen,[51, 140, 161, 190] morphine,[157] benzydamine oral rinse plus ibuprofen,[117] and metamizole.[190] Two studies

evaluated oral prednisolone[43, 62] and one evaluated the effect of amoxicillin + clavulanic acid[57] on postoperative outcomes.

Indication for tonsillectomy varied among studies. Most included a combination of patients with recurrent infection and OSDB (n=4).[43, 62, 157, 190] One study enrolled children with recurrent tonsillitis,[57] and several studies did not specify tonsillectomy indication(s) (n=6).[40, 51, 117, 139, 140, 161] All but two trials[57, 139] had low[43, 51, 117, 157] or moderate risk of bias,[40, 62, 140, 161, 190] and were included in further analyses.

Table 42. Overview of studies addressing postoperative medications for pain-related outcomes

Characteristic	RCTs	Nonrandomized trials	Total Literature
Comparisons			
Acetaminophen vs. Non-NSAID Analgesic or Acetaminophen	4	0	4
Acetaminophen vs. NSAID	1	1	2
Steroid vs. Placebo or No Steroid	2	0	2
NSAID vs. Placebo	1	0	1
Other*	2	0	2
Surgical Indication			
Throat Infection	1	0	1
OSDB + Throat Infection	3	1	4
Unspecified	6	0	6
Effectiveness Outcomes Frequently Reported			
Rescue analgesic use	5	0	5
Time to return to normal diet/activity	5	0	5
Quality of life	1	0	1
Risk of Bias			
Low	4	0	4
Moderate	4	1	5
High	2	0	2
Total N participants	**2199**	**340**	**2539**

*Antibiotic vs. no antibiotic[57] or benzydamine oral rise vs. other oral rinse[117]
N = Number; NSAID = Non-Steroidal Anti-Inflammatory Drug; OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Detailed Analysis

Six RCTs and one nonrandomized trial evaluated postoperative analgesic medications; however, only four provided effectiveness outcomes, which included need for rescue medication[40, 51, 161] and return to normal diet.[157, 161] Three studies reported postoperative PTH outcomes, but no effectiveness data.[117, 140, 190]

Analgesics

Pain-Related Outcomes

Studies investigating the need for postoperative rescue medication after tonsillectomy considered different treatment comparisons. One RCT (moderate risk of bias) randomized 282 children to celecoxib given preoperatively (6mg/kg) and twice daily (3mg/kg) postoperatively for 5 doses or placebo.[40] Children receiving celecoxib had less mean consumption of acetaminophen on postoperative days (POD) 0-2 (celecoxib 78 vs. placebo 97 mg/kg, p=0.03), but no difference in mean morphine consumption (celecoxib 0.56 vs. placebo 0.70 mg/kg, p=NS).

Another low risk of bias trial randomized 152 children undergoing tonsillectomy to acetaminophen + ibuprofen, acetaminophen alone, or ibuprofen alone (60mg per 5 mL suspension) for postoperative pain control.[51] Groups did not differ in the use of rescue analgesia in the recovery room, but after discharge from the recovery room during postoperative days 0-2, fewer patients required rescue analgesia (i.e., acetaminophen + ibuprofen) in the combination group than in the other arms (0% combined, 16% acetaminophen, 15% ibuprofen). A third study (moderate risk of bias) compared postoperative treatment with acetaminophen or diclofenac (dose NR) to be administered every 8 hours or as needed for pain.[161] Mean analgesic use did not differ between groups in the first 24 hours.

All trials assessing analgesia outcomes had short-term followup ranging from 24 to 48 hours postoperatively and assessed a heterogeneous group of medications. Available data are conflicting as to whether postoperative use of NSAIDs (celecoxib, ibuprofen, diclofenac) decreases rescue pain medication requirement in the first 24-48 hours among children post-tonsillectomy. Longer-term effectiveness of these medications cannot be gleaned from currently available data (Table 43).

Table 43. Need for rescue medications reported in studies of postoperative medications

Author, Year Study Type RoB	Comparison Groups (n)	Need for rescue medications
Merry 2013[51] RCT Low ROB	G1: Acetaminophen 120 mg+ ibuprofen 60 mg/5mL suspension (52) G2: Acetaminophen 120 mg/5 mL suspension (49) G3: Ibuprofen 60 mg/5 mL suspension (51)	**N requiring rescue analgesia, (%)** In PACU G1: 1 (2) G2: 1 (2) G3: 1 (2) Post-PACU discharge G1: 0 G2: 8 (16) G3: 8 (15)
Monem 2005[161] RCT Moderate ROB	G1: Acetaminophen (32) G2: Diclofenac (34)	**N requiring additional analgesia, (%)** G1: 3 (9) G2: 2 (6) No significant group differences in total analgesic use in first postoperative day or in at-home antiemetic use
Murto 2015[40] RCT Moderate ROB	G1: Celecoxib (141) G2: Placebo (141)	**Analgesic consumption** • No group differences in opioid consumption in PACU • No group differences in cumulative co-analgesic consumption in postoperative days 0-7 • No group differences in N morphine-free patients **Postoperative day 0-2 acetaminophen consumption, mean** G1: 78 mg/kg^{-1} (95% CI: 68 to 89) G2: 97 mg/kg^{-1} (95% CI: 85 to 109) G1 vs. G2: p=0.03 **Postoperative day 0-2 morphine consumption** G1: 0.56 mg/kg^{-1} (95% CI: 0.47 to 0.65) G2: 0.70 mg/kg^{-1} (95% CI: 0.59 to 0.81) G1 vs. G2: p=NS

CI=Confidence Interval; G=Group; kg = Kilogram; mg = Milligram; N=Number; NR=Not Reported; NS=Not Significant; PACU=Post-Anesthesia Care Unit; RCT=Randomized Controlled Trial; ROB=Risk of Bias

Return to Normal Diet

Return to normal diet was evaluated and defined differently in two studies (Table 44). In one RCT with low risk of bias, 91 children (1-10 years of age) with OSDB with or without recurrent tonsillitis undergoing tonsillectomy were randomized to postoperative acetaminophen + ibuprofen or acetaminophen + morphine.[157] Both groups used pain medications for a mean of 4 postoperative days (ibuprofen 4.64 vs. morphine 4.04 days). No difference was observed in days to return to preoperative diet between arms (morphine 7.31 vs. ibuprofen 7.17 days, p=0.89). Another moderate risk of bias trial randomized children undergoing tonsillectomy to postoperative acetaminophen or diclofenac.[161] Children in the acetaminophen group had faster return to normal oral intake compared with those getting diclofenac, and this reached significance on the first 5 postoperative days. Altogether, current data do not consistently indicate a differential return to preoperative/normal diet among children treated with NSAIDs (i.e., ibuprofen, diclofenac), morphine, or acetaminophen.

Table 44. Return to normal diet or activity in studies of postoperative medications

Author, Year Study Type Groups (N) RoB	Comparison Groups (n)	Time to Return to Normal Diet/Activity
Kelly 2015[157] RCT Low ROB	G1: Acetaminophen + morphine (46) G2: Acetaminophen + ibuprofen (38) G2: 19 (48)	N days to return to preoperative diet, mean±SD G1: 7.31±3.82 G2: 7.17±5.23 G1 vs. G2: p=NS
Monem 2005[161] RCT Moderate ROB	G1: Acetaminophen (32) G2: Diclofenac (34)	Significantly greater percent of normal diet consumed in G1 vs. G2, $p < 0.05$

G = Group; NR = Not Reported; NS = Not Significant; RCT = Randomized Controlled Trial; ROB = Risk of Bias; SD = Standard Deviation

Steroids

Return to Normal Diet

Two RCTs evaluated the effectiveness of postoperative prednisolone in children undergoing tonsillectomy (Table 45).[43, 62] In one trial (low risk of bias) 138 children (≥4 years of age) undergoing elective tonsillectomy for tonsillitis or hypertrophy were randomized to oral prednisolone (0.25 mg/kg/day) for seven postoperative days or no prednisolone.[43] No difference in type of diet (i.e., none, fluid, soft, normal) was seen between arms on POD 1 (p=0.30); however, significantly more children had normal diet (46% vs. 25%, $p < 0.001$) and a higher activity level in the prednisolone arm on postoperative day 7 (p=0.004). No difference between groups in either diet or activity was present on postoperative day 14. Although not reported specifically for children, outcomes did differ based on tonsillectomy indication. In a stratified *post hoc* analysis, those undergoing tonsillectomy for OSDB were significantly more likely to have normal diet and improved activity by postoperative day 7 if treated postoperatively with prednisolone compared with controls. These associations were not observed in patients whose indication was recurrent tonsillitis.

A second trial (low risk of bias) randomized 215 children to a 5-day postoperative course of prednisolone (0.5 mg/kg up to 20 mg/day) or placebo.[62]Time to return to preoperative diet or activity did not differ between groups (p values > 0.2). Overall, data from these studies provide

inconsistent evidence that postoperative treatment with oral prednisolone decreases time to return to preoperative/normal diet or activity level.

Table 45. Key outcomes-postoperative steroids-time to return to normal diet or activity

Author, Year Study Type RoB	Comparison Groups (n)	Time to Return to Normal Diet/Activity
Park 2015[43] RCT Low ROB	G1: Prednisolone 0.25 mg/kd/day (69) G2: No prednisolone (69)	**Normal diet at day 14 postoperative, N (%)** G1: 64 (93) G2: 65 (94) G1 vs. G2: p=NS **Normal activity at day 14, N (%)** G1: 69 (100) G2: 66 (96) G1 vs. G2: p=NS
Macassey 2012[62] RCT Moderate ROB	G1: Prednisolone (106) G2: Placebo (107)	**Time to normal diet** G1 vs. G2: p=NS **Time to normal activity** G1 vs. G2: p=NS

G=group; NR=not reported; NS=not significant; RCT=randomized controlled trial; ROB=risk of bias

Harms Associated With Postoperative Medications

PTH

Six studies of low or moderate risk of bias addressed postoperative medications for pain and reported PTH-related outcomes.[40, 43, 62, 117, 140, 190] PTH rates overall were low (Table 46). The total rate in steroid studies was higher, but numbers of PTH in steroid and placebo arms in the two studies addressing that comparison were similar (n PTH in steroid arms=13, n in placebo/no treatment arms=15).[43, 62] Rates in studies comparing NSAIDs (celecoxib, ibuprofen) to placebo or other medications were also similar (n PTH in NSAID arms=14, n in comparison arms=16).[40, 190] Rates of PTH were similar among studies of non-NSAID analgesics (2%-4%).[117, 140, 190]

Table 46. Unadjusted PTH-related outcomes in study arms evaluating postoperative medications for pain

Drug class (n arms)	Total N	Total PTH (%)	Total Primary PTH (%)	Total Secondary PTH (%)	Total Other/ Undefined PTH (%)	Total Nonoperative Readmission or Revisit for PTH (%)	Total Reoperation for PTH (%)
All arms (13)	2063	97 (4.7)	12 (0. 58)	15 (0.73)	70 (3.4)	18 (0.87)	17 (0.82)
NSAIDs (3)	679	32 (4.7)	5 (1.2)	13 (3.1)	14 (2.6)	8 (5.7)	12 (1.8)
Non-NSAID analgesics (4)	772	23 (3.0)	7 (1.7)	2 (0.49)	14 (1.8)	NR	3 (1.3)
Steroids (2)	160	13 (8.2)	NR	NR	13 (8.1)	NR	NR
Other (1)	140	6 (4.3)	NR	NR	6 (4.3)	NR	NR

No treatment/ Placebo (3)	312	23 (7.4)	NR	NR	23 (7.4)	9 (3.7)	2 (1.4)

Note: Percents for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.
N = Number; NR = Not Reported; NSAID = Non-Steroidal Anti-Inflammatory Drug; PTH = Post-Tonsillectomy Hemorrhage

Discussion

State of the Literature

We identified 197 unique studies addressing the benefits and harms of tonsillectomy (which we consider to encompass tonsillectomy, adenotonsillectomy, partial tonsillectomy or tonsillotomy). These unique studies (reported in multiple publications) comprised 136 randomized controlled trials (RCTs), 10 nonrandomized trials, six prospective and four retrospective cohort studies, and 18 database or registry studies and 23 case series. Key Questions (KQs) addressed in this review assessed the likelihood that tonsillectomy will improve clinical outcomes around throat infections and sleep disorders; the risk of harm associated with tonsillectomy, primarily post-tonsillectomy hemorrhage (PTH); and whether different approaches to tonsillectomy (e.g., partial vs. total tonsil removal, surgical technique such as coblation or laser) optimize effectiveness and minimize harms. We addressed these questions by reviewing the comparative (primarily RCT) data for effectiveness on a specific set of outcomes, then by searching a broader set of studies (case series and database or registry studies including at least 1000 children) for harms data in order to estimate the rates of the most common and most severe harms (PTH, readmission, and reoperation). While we attempted to stratify on key covariates, including BMI, documentation of throat infections, and surgical indication, such data were rarely available.

The literature on tonsillectomy in children for obstructive sleep-disordered breathing (OSDB) or recurrent throat infection is heterogeneous in terms of populations, interventions, comparators, and outcomes. Most studies included children with widely varying ages (e.g., 2 to 14 years), unspecified or mixed (both OSDB and throat infections) indications for surgery, and varying degrees of severity. Few studies stratified on potential confounding factors such as degree of tonsillar hypertrophy.

Anesthetic, analgesic, and anti-emetic regimens varied across studies, as did surgical techniques and perioperative and postoperative agents or combinations of agents assessed. Comparison groups included placebo, observation, historical control groups, and other active interventions. While studies typically addressed similar effectiveness outcomes including changes in respiratory or sleep parameters (e.g., Apnea Hypopnea Index [AHI], sleep-related quality of life), number and severity of throat infections, return to normal diet and activity, need for rescue analgesia or anti-emetics postoperatively, and behavioral outcomes, measures used to evaluate the outcomes varied. Although a large number of studies reported PTH, definitions of "bleeding" varied and ranged from episodes of blood-tinged sputum to profuse bleeding requiring reoperation for hemostasis. Outcome measures were also frequently caregiver- or child-reported pain or bleeding diaries.

Summary of Key Findings and Strength of the Evidence

KQ1. Effectiveness of Tonsillectomy for OSDB

Key Findings

Ten studies (3 RCTs, 5 prospective and 2 retrospective cohort studies) met criteria for this KQ. Relative to no intervention, most studies reported better sleep-related outcomes in children who had a tonsillectomy, but improvements were modest and risk of bias in the studies was

mixed. In five studies that included children whose OSDB was confirmed with polysomnography (PSG), AHI scores improved more in children receiving tonsillectomy than in those with no surgery (significant group differences in 2 studies).[116, 174, 197, 198, 204] Sleep-related quality of life and negative behaviors (e.g., anxiety, emotional lability) also improved more among children who had tonsillectomy.[116, 174, 204] Changes in executive function were not significantly different.[174, 197]

We did not find tonsillectomy to be superior to CPAP in the few included studies addressing this comparison. The two studies comparing these interventions had inconsistent results, with one study favoring tonsillectomy and the other reporting no difference in AHI.[46, 205] Both studies were small and included selected subsets of children (e.g., significant comorbidities or under 24 months old).

Strength of the Evidence

The strength of the evidence is low for greater improvement in AHI after tonsillectomy compared with no surgery; moderate for a modest improvement in sleep-related quality of life; and low for no effect on negative behaviors with tonsillectomy compared with no surgery (Table 47). Strength of the evidence is insufficient to assess effects on executive function and insufficient to assess effects on other outcomes including cognitive changes (IQ), cardiometabolic outcomes, and health care utilization, which were all addressed in single studies.

Strength of the evidence is insufficient to assess effects on AHI or sleep-related quality of life in two small studies with high to medium study limitations assessing tonsillectomy compared with CPAP.

Table 47. Strength of evidence for effectiveness of tonsillectomy vs. watchful waiting/no treatment for OSDB

Intervention/ Outcome Study Design Risk of Bias and Number of Studies (N Total)	Study Limitations	Consistency	Directness	Precision	Reporting Bias	Strength of Evidence Grade Finding
Tonsillectomy vs. No tonsillectomy						
AHI RCT: 2 moderate[116, 174] (N=456) Prospective Cohort: 1 high,[198] 1 moderate[197] (N=135) Retrospective Cohort: 1 moderate[204] (N=93)	Medium	Inconsistent	Indirect	Precise	Undetected	**Low SOE for greater improvement of AHI with tonsillectomy compared with no surgery** Significant but modest improvement in tonsillectomy vs. no surgery groups in 1 RCT and 1 retrospective cohort study; no significant group differences in 1 RCT and 1 prospective cohort; significance not assessed in 1 prospective cohort

Sleep-related Quality of Life RCT: 2 moderate[116, 174] (N=456) Retrospective Cohort: 1 moderate[204] (N=32)	Medium	Consistent	Direct	Precise	Undetected	**Moderate SOE for modest improvement in sleep-related quality of life after tonsillectomy vs. no surgery** Significant improvements in tonsillectomy vs. no tonsillectomy groups on measures of sleep-related quality of life in 2 RCTs and 1 cohort study in the short term
Behavioral Outcomes RCT: 1 moderate[174] (N=397) Prospective Cohort: 1 moderate[197] (N=38) Retrospective Cohort: 1 moderate[204] (N=32)	Medium	Inconsistent	Direct	Im-precise	Not suspected	**Low SOE for no effect on negative behaviors after tonsillectomy vs. no surgery** Significant improvements in tonsillectomy vs. no surgery in 1 RCT and 1 retrospective cohort; no significant differences in 1 prospective cohort; differences in measurement time frames across studies (7 months-4 years)

AHI = apnea-hypopnea index; OSDB = obstructive-sleep disordered breathing; RCT = randomized controlled trial; SOE = strength of the evidence

KQ1a. Effectiveness of Tonsillectomy for Children With OSDB and Neuromuscular or Craniofacial Abnormalities

Key Findings

While studies may have included some children with craniofacial abnormalities, only a single, small RCT compared the efficacy of tonsillectomy to immediate initiation of CPAP in children with OSDB and concurrent Down Syndrome or mucopolysaccharidoses. Both groups showed improvement in AHI at 6-month follow-up, with no significant group differences in AHI at 12 months. Three children (8.1%) who underwent tonsillectomy had persistent symptoms of OSDB and 5 children (13.8%) who initiated CPAP had persistent OSDB symptoms.

Strength of the Evidence

Strength of the evidence is insufficient to assess effects on AHI or sleep-related quality of life as only one small study with moderate risk of bias evaluated these outcomes.

KQ1b. Effectiveness of Tonsillectomy for Children With OSDB Under 3 Years of Age

Key Findings

While several studies included children less than 3 years of age, these data were not extractable from the aggregate study population data. Only one high risk of bias retrospective cohort study focused exclusively on younger children (≤2 years of age). The study reported greater improvements in AHI in children receiving tonsillectomy compared with those receiving

CPAP or other treatments.

Strength of the Evidence

Strength of the evidence is insufficient to assess effects on AHI in one small, high risk of bias study.

KQ1c. Effectiveness of Tonsillectomy for Children With OSDB and Down Syndrome

Key Findings

As noted above, only a single RCT specifically recruited children with Down Syndrome and reported data aggregated with those of children with mucopolysaccharidoses. Both modalities (tonsillectomy and CPAP) were equally effective at improving AHI, with no significant group differences.

Strength of the Evidence

Strength of the evidence is insufficient to assess effects on AHI in a single, small study with moderate risk of bias.

KQ1d. Effectiveness of Tonsillectomy for Children With OSDB and Obesity

Key Findings

Several studies included children who were overweight or obese; however, only one retrospective cohort specifically evaluated a majority overweight/obese population (75% of children) with PSG-proven OSDB and reported a significant decrease in AHI in children who received tonsillectomy compared with those who did not.

Strength of the Evidence

Strength of the evidence is insufficient to assess effects on AHI with only a small, high risk of bias study.

KQ2. Effectiveness of Tonsillectomy for Recurrent Throat Infection

Key Findings

Nine studies (5 RCTs, 2 nonrandomized trials, and 2 retrospective cohort studies) compared tonsillectomy to no surgery for recurrent throat infections. Although studies assessed infection rates and a number of utilization measures, such as missed school in the short term, longer term results were rarely reported, and studies that did report longer term results suffered from high attrition and incomplete data. In addition, “throat infection” was not defined consistently across studies and very rarely was bacterial infection confirmed.

Overall, children undergoing tonsillectomy to improve number of throat infections, associated health care utilization (clinician visits), days of work/school missed, and quality of life had improvements in these outcomes in the first post-surgical year compared with children

not receiving surgery.[9, 11, 166, 181, 203, 206] These benefits diminished over time, however, and data on the longer term outcomes are limited.

Strength of the Evidence

We considered strength of the evidence to be moderate for a modest reduction in throat infections or streptococcal infections after tonsillectomy versus no surgery in the short term (< 12 months) (Table 48). We considered the strength of evidence for reduction of infections in the longer term to be insufficient and to be low for no difference in streptoccocal infection reduction in the longer term as few studies reported longer term data, and those that did had high attrition rates. Strength of evidence is low for reduction in utilization (clinician visits) in the short term; low for improvements in missed school in the short term; low for no difference in missed school over the longer term; and low for no differences in quality of life after tonsillectomy compared with no surgery.

Table 48. Strength of evidence for effectiveness of tonsillectomy vs. watchful waiting/no treatment for recurrent throat infections

Intervention/ Outcome Study Design Risk of Bias and Number of Studies (N Total)	Study Limitations	Consistency	Directness	Precision	Reporting Bias	Strength of Evidence Grade Finding
Tonsillectomy vs. No tonsillectomy						
Throat Infection RCT: 4 moderate[9, 166, 181] 1 high [11] (N=576) Non-RCT: 1 moderate[181] 1 high[11] (N=557) Retrospective Cohort: 1 moderate[206] (N=290)	Medium	Consistent	Direct	Precise	Undetected	**Moderate SOE for modest reduction in throat infection after tonsillectomy vs. no treatment in short-term (12 months)** Lower rates of throat infection in tonsillectomy arms in short-term with narrowing of gap in longer-term followup

Streptococcal Infection (≤ 12 months post-surgery) RCT: 2 moderate[9] 1 high [11] (N=345) Non-RCT: 1 high[11] (N=78) Retrospective Cohort: 1 moderate[206] (N=290)	Medium	Consistent	Direct	Precise	Undetected	**Moderate SOE for reduction in streptococcal infection after tonsillectomy vs. no tonsillectomy in short term (12 months)** Lower rates of streptococcal infection in tonsillectomy arms in short-term with narrowing of gap in longer-term followup
Streptococcal Infection (2-3 years post-surgery) RCT: 2 moderate[9] 1 high [11] (N=245) Non-RCT: 1 high[11] (N=28) Retrospective Cohort: 1 moderate[206] (N=290)	Medium	Inconsistent	Direct	Precise	Undetected	**Low SOE for no difference in reduction in streptococcal infection after tonsillectomy vs.no surgery over longer term (2-3 years)** Lack of significant group differences in longer term followup in 3 RCTs and 1 non-RCT; similar proportion of infections in retrospective cohort; and significantly more infection in non-surgical groups in 2 RCTs
Utilization (clinician contacts) RCT: 1 moderate[181] (N=231) Non-RCT: 1 moderate[181] (N=303) Retrospective Cohort: 1 moderate[203] (N=10951)	High	Consistent	Direct	Precise	Undetected	**Low SOE for reduction in clinician contacts after tonsillectomy vs. no surgery in short term (<12 months)** Fewer consultations in tonsillectomy arms vs. no surgery, but high loss to followup and differences in outcome assessment
Quality of Life RCT: 1 moderate[181] (N=231) Non-RCT: 1 moderate[181] (N=303)	High	Consistent	Direct	Precise	Undetected	**Low SOE for no difference in quality of life after tonsillectomy vs. no tonsillectomy** Modest improvements in quality of life in both groups; SOE is low given high attrition in both studies

Missed school/work (≤ 12 months post-surgery) RCT: 3 moderate[9, 166] 1 high[11] (N=345) Non-RCT: 1 high[11] (N=78)	Medium	Inconsistent	Direct	Im-precise	Undetected	**Low SOE for improvements in missed school after tonsillectomy vs. no surgery in short term (< 12 months)** Significantly fewer missed days in tonsillectomy arms vs. no surgery in 2 RCTs with medium study limitations at 12 month followup; no differences in third RCT
Missed school/work (> 12 months post-surgery) RCT: 3 moderate[9, 166] 1 high[11] (N=245) Non-RCT: 1 high[11] (N=28)	Medium	Consistent	Direct	Im-precise	Undetected	**Low SOE for no difference in effects between in longer term (>12 months)** No significant differences between groups in all studies at longer-term followup; SOE is low given medium study limitations and relatively low number of participants

Non-RCT = nonrandomized trial; RCT = randomized controlled trial; SOE = strength of the evidence

KQ3. Effectiveness of Partial vs. Total Tonsillectomy

Key Findings

Twenty studies compared partial to total tonsillectomy, but only six compared partial and total using the same surgical technique.[55, 86-88, 92, 194] Four studies compared partial versus total cold dissection and reported no differences other than a faster return to normal diet for partial tonsillectomy.[55, 86, 88, 194] Among those comparing partial and total coblation[87] or partial and total electrocautery,[92] return to normal diet and activity were more favorable in children undergoing partial tonsillectomy compared with total.

Most studies evaluated partial vs. total tonsillectomy using differing surgical techniques (n=12), and we considered the comparison of interest in these to be "partial vs. total," although it is not possible to be certain that effects are due to the surgical technique rather than the amount of tissue removed. Differences between partial and total tonsillectomy were generally not significant for outcomes related to OSDB persistence, quality of life, or behavior in these studies.[73, 97, 99, 100, 109, 112, 141, 153, 160, 184-189]

In six studies, children in the partial tonsillectomy arms had faster return to diet and normal activity compared with total tonsillectomy; however, these effects may be due to confounding by indication as surgical indication varied across studies. Across all studies, 14 out of an estimated 220 children (6.4%) had tonsillar regrowth after partial tonsillectomy, 12 of whom ultimately underwent completion of total tonsillectomy as a revision surgery.

Strength of the Evidence

We considered strength of the evidence to be low for no difference in effects on OSDB persistence; low for faster return to normal diet after partial tonsillectomy; and insufficient to assess effects on throat infection in studies comparing partial versus total cold dissection tonsillectomy (Table 49). Strength of the evidence is insufficient to assess effects on return to normal diet or activity in studies comparing either partial and total coblation tonsillectomy or

partial and total electrocautery tonsillectomy given that only a single study addressed these outcomes.

We considered strength of the evidence to be low for a more favorable return to normal diet and activity in children undergoing partial versus total tonsillectomy and low for no difference in effects on long-term (>12 months) persistence of OSDB symptoms, quality of life, behavioral outcomes, or throat infections in studies comparing mixed techniques.

Table 49. Strength of evidence for effectiveness of total tonsillectomy vs. partial tonsillectomy

Intervention/ Outcome **Study Design** **Risk of Bias and Number of Studies (N Total)**	**Study Limitations**	**Consistency**	**Directness**	**Precision**	**Reporting Bias**	**Strength of Evidence Grade** **Findings**
Total vs.partial cold dissection tonsillectomy						
OSDB Persistence RCT: 1 low[55] (N=101) Non-RCT: 1 moderate[194] (N=1023)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no difference in effects on OSDB persistence between partial or total tonsillectomy** In both studies children in partial arm had snoring or apnea in short term but no group difference in longer followup; low SOE given few studies addressing outcome
Return to Normal Diet RCT: 1 low,[55] 1 moderate[88] (N=131)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for faster return to normal diet after partial vs. total tonsillectomy** Children undergoing partial tonsillectomy returned to normal diet approximately 4 days sooner than children undergoing total tonsillectomy according to parent report
Total vs. Partial tonsillectomy (mixed techniques)						
Return to Normal Diet or Activity RCT: 2 low,[99, 100] 4 moderate,[97, 109, 112, 187, 188] (N=620)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for more favorable return to normal diet and activity in children undergoing partial vs. total tonsillectomy** Children undergoing partial vs. total tonsillectomy had consistently favorable outcomes but unit of measure varied across studies (e.g., mean days, N children)

OSDB Persistence (≥12 months post-tonsillectomy) RCT: 3 moderate[112, 184-188] (N=214)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no difference in effects on long-term persistence of OSDB symptoms between partial and total tonsillectomy** More children undergoing partial vs. total tonsillectomy had short-term snoring or obstructive symptoms in 2 studies but no group differences in longer term in any study
Quality of Life (≥12 months post-tonsillectomy) RCT: 2 moderate[184-188] (N=159)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no long-term differences in quality of life after partial vs. total tonsillectomy** Improvements from baseline in both groups in 2 small studies, but no significant group differences in quality of life in either study
Behavioral Outcomes (≥12 months post-tonsillectomy) RCT: 2 moderate[184-188] (N=159)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no long-term differences in behavioral outcomes after partial vs. total tonsillectomy** Improvements from baseline in both groups on the Child Behavior Checklist in 2 small studies, but no significant group differences in either study
Throat Infections (≥12 months post-tonsillectomy) RCT: 1 low,[187, 188] 3 moderate[112, 141, 184-186] (N=296)	Medium	Inconsistent	Direct	Imprecise	Undetected	**Low SOE for no effect on throat infections following partial vs. total tonsillectomy** More throat infections or sore throats following partial vs. total tonsillectomy in 3 of 4 RCTs but no significant group differences

N = number; OSDB = obstructive sleep-disordered breathing; RCT = randomized controlled trial; SOE = strength of the evidence

KQ4. Effectiveness of Surgical Techniques for Tonsillectomy

Key Findings

We identified 58 unique studies (53 RCTs, 4 nonrandomized trials, and one prospective cohort study) comparing surgical techniques, few of which reported effectiveness data. Only 19 studies reported recovery-related outcomes (return to normal activity and/or diet). Frequently used "hot" techniques such as coblation and electrocautery were generally associated with faster recovery (as measured by return to normal diet or activity) than was cold dissection. Few studies, typically addressing different measures and using different comparison techniques, addressed newer techniques such as thermal welding, laser, or harmonic scalpel, thus limiting our ability to draw conclusions about these approaches.

Strength of the Evidence

Strength of the evidence is low for a faster return to normal activity associated with coblation compared with cold dissection tonsillectomy and low for a faster return to normal diet associated with electrocautery compared with cold dissection tonsillectomy (Table 50). We considered the strength of the evidence insufficient to assess effects of other surgical techniques (e.g., laser, thermal welding, harmonic scalpel) on these outcomes given that studies were typically small and evaluated different measures (e.g., dietary intake score, number of children consuming normal diet, parental return to work).

Table 50. Strength of evidence for return to normal diet or activity in studies of surgical techniques for tonsillectomy

Intervention/ Outcome Study Design Risk of Bias and Number of Studies (N Total)	Study Limitations	Consistency	Directness	Precision	Reporting Bias	Strength of Evidence Grade Finding
Coblation vs. Cold dissection tonsillectomy						
Return to normal activity RCT: 3 low[91, 146, 171, 172] 1 moderate[193] (N=276)	Low	Consistent	Direct	Imprecise	Undetected	**Low SOE for faster return with coblation** Coblation, compared with cold dissection, associated with moderately faster return to normal activity in 4 small studies
Electrocautery vs. cold dissection tonsillectomy						
Return to normal diet RCT: 1 low[136] 2 moderate[81, 129] (N=254)	Medium	Inconsistent	Direct	Imprecise	Undetected	**Low SOE for faster return with electrocautery** Electrocautery, compared with cold dissection, associated with faster return to normal diet in 2 studies and not significantly faster in a third

N = number; RCT = randomized controlled trial; SOE = strength of the evidence

Harms of Surgical Techniques

Key Findings

We included harms data reported in comparative studies and case series and database and registry studies to address this KQ; however, we considered only data from meta-analyses and comparative studies in our assessment of the strength of the evidence. Ninety-six comparative studies reported harms data, most of which were PTH-related outcomes (reported in 86 studies).

Overall, estimates of PTH and utilization harms associated with tonsillectomy are low. In meta-analyses, rates of primary and secondary PTH associated with total and partial tonsillectomy were consistently low, below 4 percent for any technique and with overlapping confidence bounds. Pooled rates (without adjustment) of PTH were low overall (3.5% in total tonsillectomy; 1.2% in partial tonsillectomy) in comparative studies. Unadjusted rates of revisits for pain, dehydration, or postoperative nausea and vomiting (PONV) were also low (< 2%). Other harms were disparate and generally not clinically significant (e.g., thermal burn from a cautery apparatus). No comparative studies reported deaths. Rates of harms in case series and database or registry studies generally aligned with rates from comparative studies. Three deaths were reported in case series including 1292993 children.

Strength of the Evidence

Strength of evidence is high for minimal PTH and PTH-associated utilization (readmissions or revisits) associated with both partial and total tonsillectomy (Table 51). Strength of the evidence is low for minimal revisits or readmission for dehydration associated with partial tonsillectomy and moderate for minimal non-bleeding readmissions/revisits associated with total tonsillectomy. Data were insufficient to assess effects on admissions or revisits for pain or PONV associated with partial tonsillectomy given the few comparative studies addressing the outcome.

Table 51. Strength of evidence for harms associated with surgical techniques for tonsillectomy

Intervention/ Outcome Study Design Risk of Bias and Number of Studies (N Total)	Study Limitations	Consistency	Directness	Precision	Reporting Bias	Strength of Evidence Grade Finding
Partial tonsillectomy						
PTH and PTH-associated utilization Meta-analysis RCT: 5 low,[55, 92, 100, 153, 169, 170]11 moderate[60, 73, 86-88, 97, 112, 141, 160, 184-188] (N=1234) Non-RCT: 2 moderate[189, 194] (N=1216)	**Medium**	**Consistent**	**Direct**	**Precise**	**Undetected**	**High SOE for minimal bleeding associated with partial tonsillectomy** Rates did not exceed 3% for PTH; fewer data available to assess associated utilization, but rates are likely low given the low rate of PTH

Readmissions /revisits for dehydration RCT: 1 low,[100] 2 moderate[87, 141] (N=221)	**Medium**	**Consistent**	**Direct**	**Imprecise**	**Undetected**	**Low SOE for minimal dehydration revisits/readmissions associated with partial tonsillectomy** 5 readmissions reported across 3 study arms
Total tonsillectomy						
PTH and PTH-associated utilization Meta-analysis RCT: 18 low,[45, 55, 58, 71, 77, 91, 92, 95, 100, 122, 125, 127, 133, 136, 146, 153, 165, 171, 172, 201] 34 moderate[9, 46, 50, 65, 66, 68, 73, 76, 81, 82, 84, 86, 88, 89, 93, 97, 98, 105, 112, 113, 118, 126, 129, 132, 141, 143, 147, 154, 160, 162, 166, 180, 187, 188, 262] Non-RCT: 1 low,[191] 5 moderate[189, 192-194, 196] Cohort studies: 1 low,[201] 1 moderate[206] (N=8069)	**Medium**	**Consistent**	**Direct**	**Precise**	**Undetected**	**High SOE for minimal bleeding associated with total tonsillectomy** Low rates of PTH and PTH-associated utilization in both meta-analysis and unadjusted analyses (<6% associated with commonly used techniques)
Readmissions for pain, PONV, dehydration RCT: 9 low,[45, 68, 71, 95, 105, 116, 125, 127, 136] 8 moderate[76, 112, 113, 118, 126, 132, 156, 166] (N=2269) Prospective cohort: 1 low[201] (N=29) Retrospective cohort: 1 moderate[206] (N=145)	**Medium**	**Consistent**	**Direct**	**Precise**	**Undetected**	**Moderate SOE for minimal non-bleeding readmissions/revisits associated with total tonsillectomy** In 37 study arms, overall rates for non-bleeding revisits/readmissions were below 2%; SOE is moderate given smaller sample size

N = number; RCT = randomized controlled trial; SOE = strength of the evidence

KQ5. Effectiveness of Adjunctive Perioperative Medications to Improve Outcomes After Tonsillectomy

Key Findings

We identified 47 RCTs and one nonrandomized trial addressing this KQ. A variety of medications have been the focus of research including different steroids (dexamethasone, prednisolone), NSAIDs (diclofenac, ibuprofen, ketoprofen, lornoxicam, ketorolac), and anti-emetics (ramosetron, granisetron, dolasetron, ondansetron). Twenty-three studies addressed steroids; 16 addressed NSAIDs; and 9 addressed anti-emetics. Nine studies addressed combinations of agents. Studies were heterogeneous, addressing multiple agents, combinations of agents, routes of administration and dosage, timing of agents, and rescue medications provided. This heterogeneity limits our ability to draw conclusions about perioperative medications.

NSAIDs. Trials evaluating perioperative use of NSAIDs reported that diclofenac administration generally reduced immediate postoperative pain requirements compared with placebo. Results from the five trials involving ibuprofen or ketoprofen inconsistently showed reduced analgesic need in the PACU.[49, 96, 108, 130, 159] A single trial of lornoxicam showed no difference in 24 hour analgesic requirement.[144] In contrast, the one study of perioperative ketorolac showed reduced pain medication needs in the PACU, but not over the first 24 hours.[119] A single study found no effect of NSAIDS on reducing anti-emetic use.[163] Prophylactic use of perioperative 5-HT receptor antagonists for prevention of postoperative need for rescue was assessed in three RCTs. NSAIDs were not associated with a faster return to normal diet or activity.[74, 128]

Steroids. Most placebo-controlled steroid trials (5/8) found that perioperative intravenous dexamethasone administration reduced the need for analgesics immediately after surgery (PACU and up to 24 hours postoperatively), but no longer term results were reported.[52, 121, 148-150] Two studies reported that peritonsillar infiltration of dexamethasone also reduced immediate postoperative analgesic requirements (PACU, surgical day ward) compared with placebo.[41, 53]

Five RCTs found perioperative steroid administration decreased postoperative anti-emetic use in the immediate postoperative period (PACU and up to 24 hours postoperatively).[59, 64, 80, 121, 148] Steroids had little effect on return to normal diet in two RCTs.[114, 137]

Anti-emetics. Data were consistent in terms of antiemetic medications. All five trials of 5-hydroxytryptamine (5-HT) receptor antagonists found their administration to have no effect on postoperative analgesic requirements.[90, 120, 124, 134, 135] Three trials consistently reported reduced postoperative antiemetic requirements in patients treated with intraoperative 5-HT receptor antagonists.[120, 124, 138]

Strength of the Evidence

We considered the strength of the evidence for studies with placebo comparison in most cases given the heterogeneity of agents and comparators (Table 52). We considered the drug class (instead of individual agent such as diclofenac) in assessing strength of evidence for NSAIDs and anti-emetics. All steroid studies addressed dexamethasone.

NSAIDs. Strength of the evidence is low for reduced need for analgesia and for no effects on return to normal diet or activity with perioperative NSAIDs given inconsistent findings in small studies. It was also low for minimal PTH and associate utilization. Evidence is insufficient to assess non-bleeding related readmissions or revisits as few studies addressed these outcomes.

Steroids. Strength of evidence is low for a reduced need for analgesics or anti-emetics associated with steroids (IV or infiltrated dexamethasone). While most studies reported reductions associated with perioperative steroids, roughly half of studies addressing each outcome reported no group differences. PTH and related utilization was low across studies (moderate strength of evidence for minimal bleeding). Evidence is insufficient to assess the effects of steroids on return to normal diet as the two small studies addressing the outcome reported inconsistent results. Only one study addressed return to normal activity (insufficient strength of evidence). Evidence is also insufficient to assess non-bleeding related readmissions or revisits as few studies reported these outcomes.

Anti-emetics. Strength of evidence is moderate for no effect of 5-HT perioperative anti-emetics on postoperative analgesia requirements and low for reduced need for postoperative anti-emetics given the small number of children evaluated in these studies.

Table 52. Strength of the evidence for studies addressing perioperative medications

Intervention/ Outcome **Study Design** **Risk of Bias and Number of Studies (N Total)**	**Study Limitations**	**Consistency**	**Directness**	**Precision**	**Reporting Bias**	**Strength of Evidence Grade Finding**
NSAID vs. Placebo						
Return to Normal diet and activity RCT: 2 moderate[74, 128] (N=180)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no difference in return to normal diet or activity with NSAIDs vs. placebo** No significant group differences in 2 small studies with medium study limitations
Need for rescue analgesic RCT: 3 low[96, 130, 158], 2 moderate[123, 144] (N=345)	Medium	Inconsistent	Direct	Imprecise	Undetected	**Low SOE for reduced need for rescue analgesia with NSAIDs vs. placebo** Significantly less need in 4 small studies, no group differences in a 5th study

PTH and PTH-related revists/ readmissions RCT: 1 low[42], 5 moderate[49, 108, 119, 152, 163] (N=277)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for minimal PTH or PTH-related revisits/readmissions associated with perioperative dexamethasone** Rates of PTH or associated utilization <3% (unadjusted analyses) in 277 children receiving NSAIDs
Dexamethasone vs. Placebo						
Need for rescue analgesic RCT: 4 low, [52, 107, 121, 148] 6 moderate[47, 80, 111, 128, 149, 150] (N=979)	Medium	Inconsisten t	Direct	Precise	Undetected	**Low SOE for reduction in analgesic need with dexamethasone vs. placebo** Significantly less need for analgesics after dexamethasone (IV or infiltration) vs. placebo in 7 small studies; no significant differences in 3 studies; inconsistency precludes higher SOE
Need for rescue anti-emetic RCT: 4 low[59, 107, 121, 148], 4 moderate[64, 80, 111, 128] (N=812)	Medium	In-consistent	Direct	Precise	Undetected	**Low SOE for reduction in anti-emetic need with dexamethasone vs. placebo** Significantly less need for anti-emetics after dexamethasone vs. placebo in 5 small studies; no significant differences in 3 studies; inconsistency precludes higher SOE
Dexamethasone						
PTH and PTH-related revists/readmis sions RCT: 6 low,[56, 59, 61, 107, 114, 121] 3 moderate[47, 80, 150] (N=873)	Medium	Consistent	Direct	Precise	Undetected	**Moderate SOE for minimal PTH or PTH-related revisits/readmissions associated with perioperative dexamethasone** Rates of PTH or associated utilization <5% (unadjusted analyses) in 873 children receiving steroids
5-HT Anti-emetics vs. Placebo or Other Comparators						

Need for rescue analgesic RCT: 4 low[90, 120, 134, 135] 1 moderate[124] (N=964)	Low	Consistent	Direct	Precise	Undetected	**Moderate SOE for no effect of anti-emetics (5-hydroxytryptamine [5-HT] receptor antagonists)** No significant group differences in 5 RCTs comparing 5-HT antagonists with other anti-emetics, other 5-HT antagonists, or placebo
Need for postoperative rescue anti-emetic RCT: 2 low[120, 138] 1 moderate[124] (N=303)	Low	Consistent	Direct	Imprecise	Undetected	**Low SOE for reduced need for postoperative anti-emetics with perioperative 5-HT anti-emetics vs. placebo** Significantly less need for postoperative anti-emetics in 3 small RCTs comparing 5-HT antagonists and placebo; imprecision precludes higher SOE

KQ6. Effectiveness of Postoperative Medications for Pain After Tonsillectomy

Key Findings

Eleven studies (10 RCTs and 1 nonrandomized trial) provided data to assess the role of postoperative medications on pain management. Study drugs included steroids (prednisolone), NSAIDs (diclofenac, ibuprofen, celecoxib, aspirin), non-NSAID analgesics (acetaminophen) and antibiotics (amoxicillin). Few studies addressed the same interventions and comparisons, and studies typically reported on need for rescue pain medication, PTH, and return to normal diet or activity as outcomes. The data on whether NSAIDS decrease rescue pain medication in the first 24 to 48 hours after surgery are conflicting, and no long-term data are available. Two studies compared prednisolone and placebo and found no effect on return to normal diet or activity.[43, 62]

PTH rates overall were low. The rates of PTH in steroid and placebo arms in the two studies addressing that comparison were similar.[43, 62] PTH rates in studies comparing NSAIDs (celecoxib, ibuprofen) and non-NSAID analgesics to placebo or other medications were also similar.[40, 51, 139, 140, 157, 161, 190]

Strength of the Evidence

Strength of evidence is low for no difference in effects on return to normal diet or activity between steroids and placebo and low for PTH associated with NSAIDs (Table 53). Strength of the evidence for the effect of postoperative analgesics on need for rescue medications or return to normal diet or activity is insufficient given that no studies addressed the same agents and comparators. Strength of evidence for PTH associated with steroids is low for no difference between steroids and placebo or no treatment and insufficient for PTH associated with other postoperative medications as no studies evaluated the same agents and comparators.

Table 53. Strength of evidence for effectiveness of postoperative medications for pain-related outcomes

Intervention/ Outcome Study Design Risk of Bias and Number of Studies (N Total)	Study Limitations	Consistency	Directness	Precision	Reporting Bias	Strength of Evidence Grade Finding
Prednisolone vs. Placebo						
Return to Normal Diet or activity in longer term (≥5 days) RCT: 1 low,[43] 1 moderate[62] (N=331)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no difference in effects of prednisolone vs. placebo on return to normal diet or activity** Number of children consuming normal diet or engaging in normal activity did not differ at 14 days post-tonsillectomy in one study; time to return to normal diet or activity did not differ in second small RCT
PTH RCT: 1 low,[43] 1 moderate[62] (N=331)	Medium	Consistent	Direct	Imprecise	Undetected	**Low SOE for no difference in PTH associated with steroids vs. placebo/no treatment** Numbers of PTH in steroid and placebo arms were similar in 2 studies (13 PTH in steroid arms vs. 15 in placebo/no treatment)
NSAIDs						
PTH RCT: 2 moderate[40, 140] (N=564) Non-RCT: 1 moderate[190] (N=115)	Medium	Consistent	Direct	Precise	Undetected	**Low SOE for minimal PTH** Unadjusted rates ranged from 0-6% across agents; higher rates associated with celecoxib; SOE is low given small sample size

RCT = randomized controlled trial; SOE = strength of the evidence

Findings in Relation to What is Already Known

We identified 23 recent (2011-present) systematic reviews or meta-analyses assessing tonsillectomy.[6, 23-27, 29-32, 269-281] Most reviews or meta-analyses (n=9) addressed perioperative medications and PTH risk or other morbidity: three addressed NSAIDs; five addressed dexamethasone; and one addressed antibiotics. Most reviews or meta-analyses included more than 1000 children (n=16). Two reviews addressed tonsillectomy for recurrent tonsillitis; six addressed tonsillectomy for OSDB (including one comparing partial and total tonsillectomy in children with OSDB and two comparing outcomes among children with or without OSA or with obesity); and five addressed partial vs. total tonsillectomy or specific surgical techniques.

Across reviews, investigators commented on methodologic limitations such as lack of blinding and limited allocation concealment; heterogeneity of techniques and indications for tonsillectomy; use of subjective outcome measures; short-term followup; small sample sizes; and generally low to moderate quality studies. Appendix I includes an overview of findings of all reviews.

Findings in prior reviews and meta-analyses generally aligned with our findings in the current report. Reviews of tonsillectomy specifically in children with OSDB or tonsillitis reported modest benefits in obstructive symptoms or sore throat reduction, typically in the short-term, for tonsillectomy compared with no surgery. Reviews comparing partial and total tonsillectomy reported few differences between techniques: partial tonsillectomy was generally associated with faster recovery (return to normal diet and activity, pain) and less PTH, but differences in resolution of OSDB symptoms or recurrent throat infections were not significantly different between approaches. Reviews comparing surgical techniques (e.g., coblation, electrocautery) similarly reported few significant differences among techniques. Reviews of perioperative steroids consistently reported no significant association with PTH in children, though one review reported greater need for reintervention when PTH occurred. Reviews of perioperative NSAIDs and PTH risk were less consistent, with two reporting no increased risk in children and one noting insufficient data to rule out risk. One review of antibiotics reported no evidence for a consistent effect of antibiotics on pain, PTH, or need for pain medications. Finally, in one review assessing weight gain in a general population of normal and overweight children undergoing tonsillectomy, participants gained more weight than expected postoperatively.

Applicability

Studies included in this review typically did not describe populations adequately, which makes applicability difficult to assess. As would be expected, studies addressing KQ1 (tonsillectomy in children with OSDB) and KQ2 (tonsillectomy in children with recurrent throat infection) specified surgical indication and generally provided greater characterization of study participants. Baseline severity of throat infection or OSDB varied across these studies as did definitions of "cure" or resolution of symptoms. Of note, the largest U.S.-based RCT addressing tonsillectomy vs. no surgery for children with OSDB included a majority African-American and majority overweight or obese population[173-180] as did two additional studies addressing this comparison.[116, 204] Two other studies addressing this comparison included a majority of children with Down Syndrome or mucopolysaccharidoses[46] or children under 2 years of age.[205] Three RCTs addressing tonsillectomy vs. no surgery for recurrent throat infection explicitly included children with mild to moderate baseline symptoms.[166-168, 282] Four larger studies addressing this comparison (2 studies reported in each paper) included majority White populations.[9, 11]

Studies addressing surgical approaches and peri- or post-operative medications typically did not specify surgical indications or included both children with OSDB or recurrent throat infections without stratifying analyses. Roughly a third of studies were conducted in less developed countries in which surgical techniques and procedures may vary from those used in the United States. Regardless of country of conduct, anesthetic approaches, analgesic agents and dosing, surgical expertise, and surgical and hemostatic techniques (including definitions of "partial tonsillectomy") varied widely across studies. Studies reporting weight or BMI typically did not address whether children were under- or over- weight for age at baseline, and few studies reported baseline comorbidities such as asthma or Down Syndrome; thus assessing applicability

to these sub-populations is challenging. Most studies used subjective outcome measures or relied on caregiver- or child-completed diaries to assess longer term outcomes. Objective measures such as the AHI or other PSG parameters may not accurately reflect effects on the totality of symptoms associated with OSDB (e.g., behavioral issues, sleepiness, overall quality of life).[175, 177, 283, 284]

Despite these limitations to generalizability, findings reported here are likely widely applicable given the heterogeneous population of children without comorbidities who undergo tonsillectomy. Applicability of findings to children with Down Syndrome, craniofacial abnormalities, obesity, or under age 2 is limited. While studies included some children with these comorbidities or in the younger age range, few provided explicit analyses of these subgroups. Appendix G includes applicability tables for each KQ.

Implications for Clinical and Policy Decisionmaking

This review provides evidence for decisionmaking in the care of children who are potential candidates for tonsillectomy. Despite the large body of literature, evidence is inadequate to provide clear evidence for consistent, and long-term benefit either for OSDB or throat infection. Thus, individual decisionmaking needs to balance short term needs for relief of illness-related outcomes (including missing school and work) with the risks associated with surgery. In cases where families are choosing between surgery and CPAP for OSDB, evidence is insufficient to support a decision. Families with children in special subgroups, including those with Down syndrome, similarly cannot rely on scientific evidence for their decision. There is modestly more evidence in the literature on throat infection, but the benefit of surgery is in the short term and not maintained over the long term. This suggests that if families are able to manage their children's illnesses for a period of time, they may outgrow the propensity for infection and be able to avoid surgery. That said, decisions are clearly in the hands of families and their clinicians and should be made on an individual basis. Harms are rare and generally minor, and clinicians have information from this review with which to counsel their patients and families.

Similarly, benefits of specific approaches to tonsillectomy (either partial versus total or by surgical technique) provide little clear guidance for clinicians. Some evidence suggests that partial removal may speed time to recovery relative to total removal; however, indication and severity are clearly important considerations for a decision around what approach to use, in addition to willingness to risk a potential 6% rate of regrowth that could require further surgery.

PTH was low across all surgical instrumentation approaches, and no clear evidence exists for a superior approach. It is likely that familiarity with a technique and surgical skill have a role in driving outcomes.

Decisional dilemmas still exist regarding the perioperative use of medication and whether they speed postoperative return to normal diet and activity and reduce the need for post-tonsillectomy analgesia and rescue anti-emetic use. Clinical care would be improved by optimizing perioperative use of medication to improve outcomes. The literature base on this subject was insufficient to provide guidance on whether any perioperative medications reduce time to normal diet or activity. However, there was low strength to evidence to suggest that a single dose of IV dexamethasone intraoperatively does reduce analgesic requirement in the PACU and up to 24h postoperatively. Evidence is mixed whether dexamethasone reduces the need for postoperative rescue anti-emetics. In contrast, clinicians can have some confidence that pre-emptive 5-HT receptor antagonists given intra-operatively do reduce the need for rescue anti-emetics post-tonsillectomy.

Limitations of the Comparative Effectiveness Review Process

We included studies published in English only and did not seek or include unpublished data. We scanned a random sample of 100 non-English abstracts retrieved by our MEDLINE search (25 selected from each decade 1980 to 2015). Most studies appeared to be case series, narrative reviews, imaging or basic science studies, or studies dealing with malignant lesions. Only two studies appeared to meet inclusion criteria; thus, given the high percentage of ineligible items in this scan (98%), we concluded that excluding non-English studies will not introduce significant bias into the review. We also included only studies of perioperative NSAID, steroids, and anti-emetics to address KQ5. While this undoubtedly means that some medications are not included in this review, these drug classes comprise key agents frequently used in the perioperative period. Given heterogeneity in anesthetic regimens, surgical techniques, postoperative analgesia and medications, and patient populations themselves, as well as the few studies that addressed questions about the need for tonsillectomy compared with a non-surgical treatment, we were limited in our ability to stratify findings or identify potential subgroups that may respond more favorably to tonsillectomy or to supportive care.

Limitations of the Evidence Base

A relatively large number of studies have been published on tonsillectomy, including for OSDB and throat infections, but risk of bias is mixed, with fewer studies (32%) having low risk of bias. Furthermore, most available studies provided little to no clinical outcome data, focusing instead on intermediate outcomes and harms. Patient populations were generally poorly characterized, and little information was available on first-line treatment attempts prior to surgery. Very few studies focused on high risk or special populations at particular risk.

Particularly in studies intended to assess effects of tonsillectomy on throat infections, parents of severely affected children were noted to refuse randomization and cross over to surgery at high rates. Long-term effects are limited in the literature base, particularly regarding outcomes that include growth/development, sleep quality outcomes, and behavioral outcomes for children with OSDB. Exploration of demographics of patient populations more likely to be refractory to initial management strategies is also limited. It appears clear that throat infections decline in children over time regardless of treatment group, but with high loss to followup, the relative contribution of this decline on apparent effectiveness is unknown.

A particular problem in the literature is a lack of full characterization of the patient population, particularly around clinically documented severity of both sleep-disordered breathing and throat infections. In the context of general lay expectations of the benefit of tonsillectomy, and common opinions that tonsillectomy is a “minor” surgery, it is possible that patients undergoing tonsillectomy may vary widely in the severity of their clinical states. Among those studies focused on throat infection that did characterize patients, most had low numbers of reported infections, and few reported culture-confirmed bacterial infections.

Of particular importance for this surgical topic is a complete assessment of potential harms, particularly PTH rates, including PTH that leads to further intervention. However, the degree and timing of PTH was rarely defined or measured; thus outcomes can only be broadly defined in terms of primary versus secondary PTH, readmissions, and reoperations, where reported. Similarly, in attempting to assess partial versus total tonsillectomy we note that partial tonsillectomy was rarely precisely specified, and these studies most often used different

techniques for the partial and total tonsillectomy, thus introducing confounding that cannot be disentangled.

Research Gaps and Areas for Future Research

Tonsillectomy is heavily researched, with far more data available to assess safety than efficacy. Despite the abundance of research, the literature is largely silent on the natural history that would provide a basis for the need for tonsillectomy in the long term. Indeed, it appears as though many young patients may outgrow the need for intervention, but more data are needed to describe this process and likelihood for parents and to describe population factors that may predict resolution.[177, 285, 286] Long-term data are needed in order for parents to weigh the benefits of surgery versus the reality of managing their child's condition as they wait for it to resolve. Future studies should take more care to characterize patient populations completely such that applicability can be much more specifically described and potential candidates for surgery or watchful waiting identified.

As new technologies for tonsillectomy emerge, as they continuously have over the last few decades, high quality research will continue to be needed to evaluate these technologies, both in terms of efficacy and safety. As we learn more about the deleterious effects of sleep apnea and detection rates increase, more refined and specific treatment algorithms will be in demand. Related to this issue, more data are needed on the use of CPAP in children as an initial modality; such data should address compliance and duration of use.

Future research should also address the current gaps in data surrounding treatment of special populations including very young children and children with relevant comorbidities such as obesity and neuromuscular disease. Further, concerns about perioperative and postoperative management persist, including over-narcotization and potential respiratory suppression. Better data regarding optimal medication regimens are essential, both in terms of symptomatic relief and minimizing iatrogenic harm.

Finally, relatively little data exist regarding predictable factors contributing to failure of tonsillectomy for primary management of OSDB and throat infections. A better understanding of these factors would allow for more specific patient selection.

Conclusions

Tonsillectomy can effect modest short-term improvement in sleep outcomes and reduction in throat infections compared with no surgery in children with OSDB or recurrent throat infections. Data on longer term results are lacking. This modest short-term improvement must be weighed against a relatively low risk of PTH. Surgical technique had little bearing on either outcome or PTH risk. Perioperative use of dexamethasone and pre-emptive 5-HT receptor antagonist anti-emetics should be considered to improve pain and reduce vomiting in the immediate postoperative period. Little evidence addressed the use of postoperative medications for pain-related outcomes.

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